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# MANUAL OF SURGERY

BY

ALEXIS THOMSON, F.R.C.S.ED.

PROFESSOR OF SURGERY, UNIVERSITY OF EDINBURGH; SURGEON EDINBURGH  
ROYAL INFIRMARY

AND

ALEXANDER MILES, F.R.C.S.ED.

SURGEON EDINBURGH ROYAL INFIRMARY

VOLUME THIRD

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*WITH 220 ILLUSTRATIONS*

EDINBURGH, GLASGOW, AND LONDON

HENRY FROWDE AND HODDER & STOUGHTON

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# MANUAL OF SURGERY

## CHAPTER I

### OPERATIONS ON BLOOD VESSELS

SUTURE OF ARTERIES—Arteriorrhaphy. RADICAL OPERATION FOR ANEURYSM (Matas' Operation)—Endo-aneurysmorrhaphy: *Varieties*—Extirpation of Sac (Old Operation)—Intra-saccular Ligation. OPERATION FOR ANEURYSMAL VARIX. OPERATION FOR VARICOSE ANEURYSM. REVERSAL OF CIRCULATION. LIGATION OF ARTERIES IN CONTINUITY.

### SUTURE OF ARTERIES—ARTERIORRHAPHY

ALTHOUGH numerous attempts have from time to time been made to close wounds in the walls of large arterial trunks by suture, it is only within recent years that the procedure has been placed on a satisfactory footing, chiefly through the work of American, German, and Italian surgeons.

For a slit in the wall of the artery, *lateral arteriorrhaphy* is performed; for complete division, *end-to-end suture* or *circular arteriorrhaphy*. These operations are indicated only in large trunks, such as the common and internal carotid, the femoral, the popliteal, the subclavian, and the axillary, in which ligation of the vessel endangers the vitality of the area supplied by it, from insufficiency of the collateral anastomosis. They are

contra-indicated if the vessel wall is contused and lacerated, if more than three-quarters of an inch of the artery is destroyed, or if infection is present.

The artery is exposed for an inch or more above and below the part to be sutured, and the circulation may be controlled by a tourniquet, or by suitable clamps, such as Crile's or Dorrance's, or by a piece of sterilised tape applied sufficiently tightly to arrest the blood stream without injuring the coat of the vessel. The smallest round needles, carrying the finest intestinal silk, are used. To diminish the risk of thrombosis, Carrel recommends that the edges to be sutured and the silk be coated with sterilised vaseline. To this end also it is important that the edges of the intima should be accurately opposed, so that the surface towards the lumen is as smooth as possible, with no cut margin or line of sutures exposed to the blood stream.

**Lateral Arteriorrhaphy.**—The object aimed at in this procedure is to close the opening in the vessel wall in

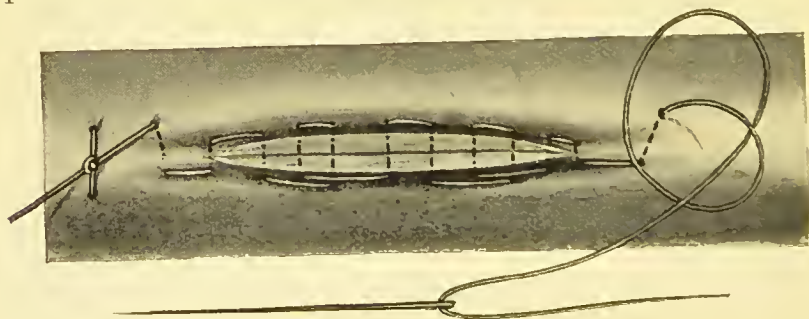


FIG. 1.—Dorrance's Suture for Lateral Arteriorrhaphy—a continuous mattress suture with "throw-back" in every third loop. (After F. F. Burghard.)

such a way as to arrest hæmorrhage, to avoid the formation of a thrombus in the lumen, and to prevent the subsequent formation of an aneurysmal dilatation at the seat of the cicatrix. A continuous mattress suture is introduced through all the coats of the vessel in such a way as to bring the edges of the intima into accurate



apposition without inverting them (Fig. 1). This line of sutures should be reinforced by a continuous stitch passing through the outer and middle coats only (Fig. 2), and over this the sheath of the vessel or the deep fascia

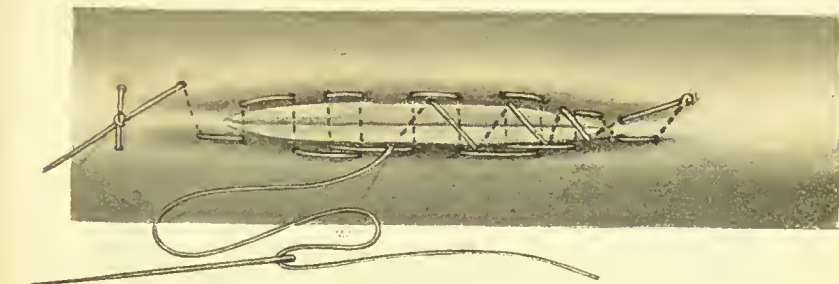


FIG. 2.—Dorrance's Suture for Lateral Arteriorrhaphy—continuous suture approximating superficial edges of wound. (After F. F. Burghard.)

may be stitched. The overlying soft parts are individually brought together with buried sutures and the wound closed without drainage.

**Circular Arteriorrhaphy.** — Various methods of performing end-to-end suture have been recommended. J. B. Murphy's plan of invaginating the proximal into the distal end is open to the theoretical objections that it stretches the artery and narrows the lumen. It has, however, yielded many satisfactory results. Dorrance secures a broad marginal confrontation of the intima by means of mattress sutures passed through all the coats of the vessel, in the same way as for lateral arteriorrhaphy, and supplemented by a continuous suture through the middle and outer coats only (Fig. 3). Carrel's method is perhaps the simplest and most efficient. The ends having been brought into apposition, three traction sutures are introduced through the adjacent margins at equidistant points of the circumference. By pulling upon two of these the part of the vessel between them is made into a straight line, and a continuous suture is passed through

all the coats so as to approximate the intima accurately without inversion.

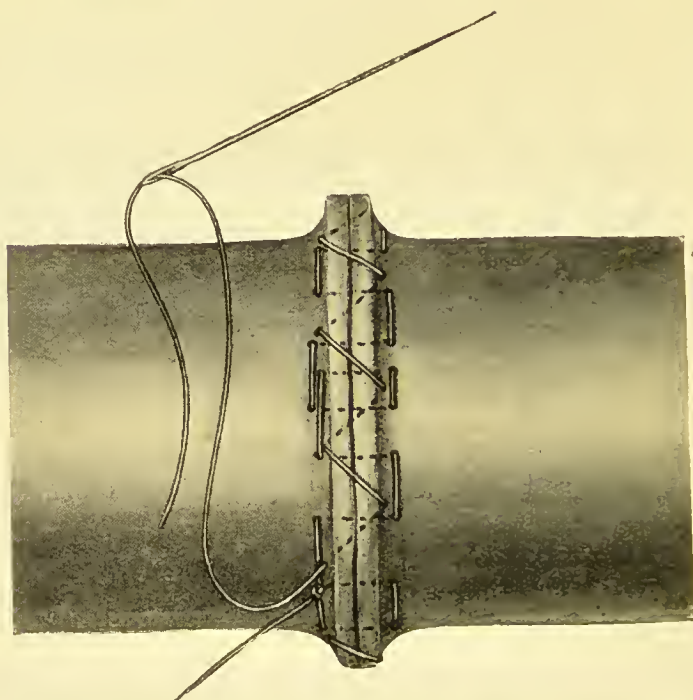


FIG. 3.—Dorrance's Suture for End-to-end Union of an Artery. (After F. F. Burghard.)

## RADICAL OPERATIONS FOR ANEURYSM

**ENDO-ANEURYSMORRHAPHY** (*Matas' Operation*).—The method of treating aneurysm directly by intra-saccular suture, first practised by Rudolph Matas in 1888, and since improved and elaborated by him, has to a large extent superseded the various procedures hitherto employed for the obliteration or complete removal of the sac.

Matas' operation is based on the fact that an aneurysmal sac is lined with an endothelial membrane identical with the intima of the parent vessel, and that if the internal surfaces of the sac are brought into close

apposition by suture they will adhere by plastic lymph, and ultimately unite in the same way as two peritoneal surfaces. The method is available, therefore, only when there is a well-formed sac, as in the typical saccular and fusiform varieties of aneurysm. Cases of recent traumatic aneurysm, in which a true sac has not had time to develop, are not suitable.

The opening between the parent vessel and the sac, as well as those of any collateral branches communicating with the sac, must be securely closed by suture to ensure hæmostasis, and to prevent the access of blood to the sac. The sac is then obliterated by approximating its walls with buried sutures in such a way as to promote their adhesion.

*Technique.*—For the satisfactory performance of Matas' operation, complete arrest of the circulation through the aneurysm is essential. In peripheral aneurysms this may be ensured by the use of an Esmarch's tourniquet; in those near the trunk or at the root of the neck, by suitable clamps or temporary ligatures applied above and below the aneurysm. To give free access to the interior and to avoid lowering its vitality, the sac is laid freely open, without being separated from its surroundings. Round needles, carrying chromic gut or fine intestinal silk lubricated with sterile vaseline, are employed in the suturing.

Three plans of performing endo-aneurysmorrhaphy have been devised by Matas: (1) The *obliterative*, in which the parent vessel is occluded where it enters and leaves a fusiform sac; (2) the *restorative*, in which the communication between the parent vessel and a saccular aneurysm is closed, leaving the lumen of the artery intact; and (3) the *reconstructive*, in which a new channel connecting the two ends of the parent vessel is formed from the wall of the sac. This last plan is only applicable to cases of fusiform aneurysm in which the walls of the sac are firm, elastic, and resistant.

**Obliterative Endo-aneurysmorrhaphy.**—This plan is to be selected in cases of fusiform aneurysm, in which the walls, being thinned out or the seat of atheromatous degeneration, are unsuitable for making a new channel between the ends of the parent trunk. The sac having been freely incised, all openings into it are closed with sutures carried through all the coats of the vessel (Fig. 4).

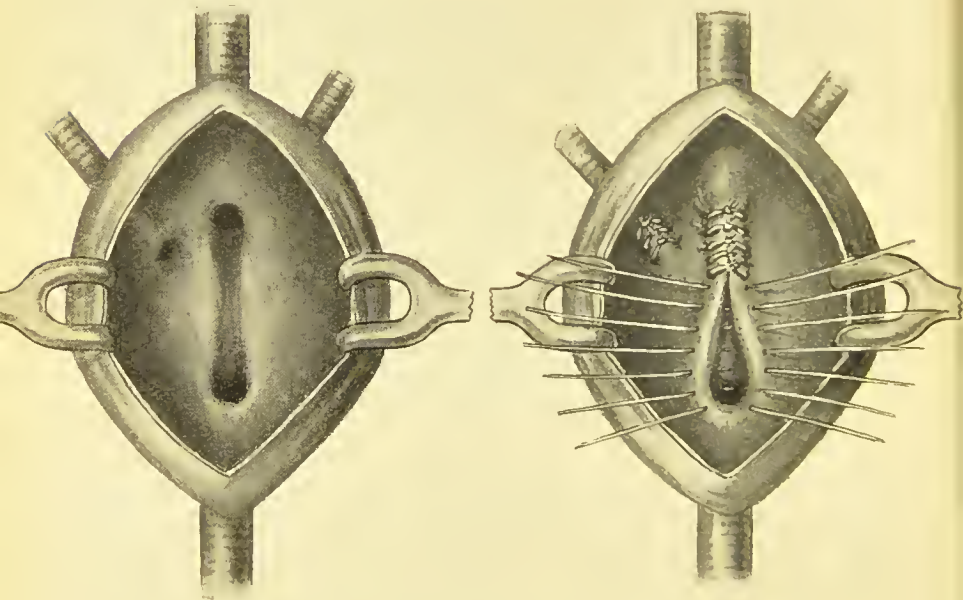


FIG. 4.—Obliterative Endo-aneurysmorrhaphy, showing Closure of Communication between the Sac and the Artery, and of a Branch leaving the Sac. (After Matas.)

The redundant sac is then obliterated by buried sutures (Fig. 5), and the wound closed, with or without drainage, according to circumstances.

If the walls of a fusiform aneurysm are strong and resistant, and the openings of the parent vessel are opposite one another and not far apart, the **reconstructive** operation may be performed (Fig. 6).

A piece of rubber catheter, lubricated with sterile vaseline, is passed into the parent vessel above and below



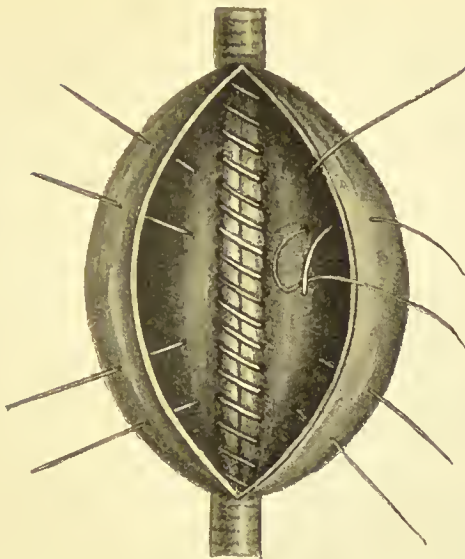
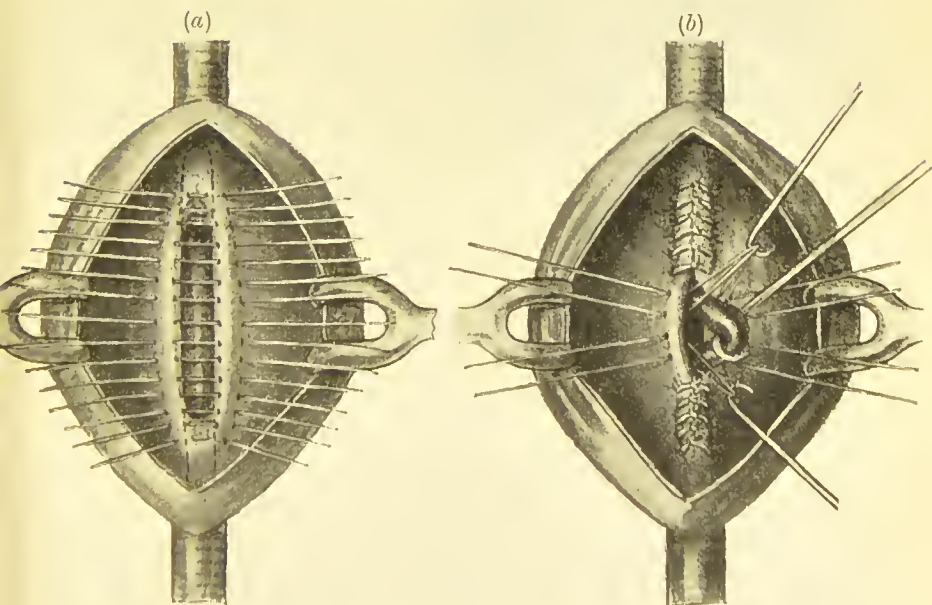


FIG. 5.—Endo-aneurysmorrhaphy—communication with Parent Vessel closed with continuous Suture; and Sutures introduced to obliterate the wall of the Sac. (After Matas.)



6.—Reconstructive Endo-aneurysmorrhaphy. (a) Sutures inserted over Rubber Tube; (b) Tube being withdrawn as Sutures are tightened. (After Matas.)

the sac, and over this as a scaffolding the walls of the sac are folded—very much as the stomach wall is folded over the tube in performing gastrostomy by Witzel's method—and united by a continuous suture passed through all the coats. Before tying the suture the catheter is withdrawn. The first row of sutures is re-

inforced by a second, and any redundant sac left is obliterated by buried sutures (Fig. 5).

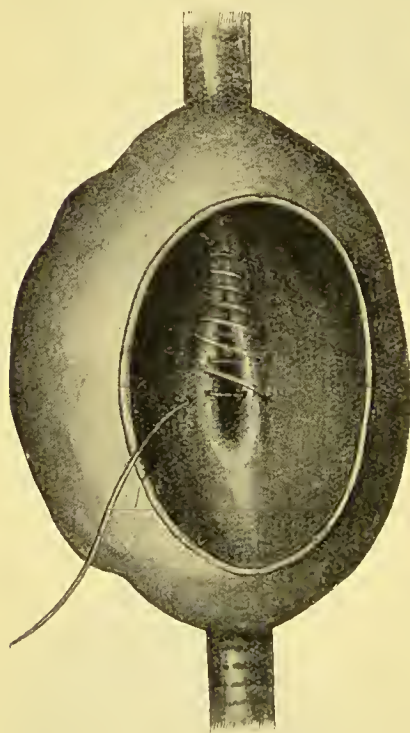


FIG. 7.—Restorative Endo-aneurysmorrhaphy. Orifice between Artery and Sac closed by continuous Suture. (After Matas.)

The **restorative operation** is adapted to the saccular aneurysm. After washing away all detachable clots from the inside of the sac, the communication with the parent vessel is exposed, and closed with a continuous suture (Fig. 7). The remainder of the sac is then obliterated by buried sutures, and the external wound closed.

#### EXTIRPATION OF THE SAC (THE "OLD" OPERATION).—

The method of treating circumscribed saccular aneurysms of the limbs practised by Antyllus (A.D. 300), and revived by Syme in 1837, has been largely superseded by the procedures of Matas. When possible, the circulation is controlled by means of a Petit's screw tourniquet, and the parent trunk is then exposed by dissection above and below the sac, and secured by a ligature. The sac is now freely opened, the clots turned out, and any collateral branches leaving the



aneurysm are secured outside the sac, a probe being passed as a guide into the lumen of each and withdrawn as the ligature is tightened (Annandale). The sac may then be dissected away, and if the vein is adherent to it, the adherent portion may be removed without materially adding to the risk of gangrene. If extirpation is impracticable, the sac is packed with gauze and allowed to granulate.

Syme extended the use of this method to aneurysms of the subclavian, carotid, and external iliac arteries, controlling the hæmorrhage by plugging the feeding artery with his finger after opening the sac. After the clots had been cleared out, the other branches were secured by ligature. The hæmorrhage from the distal end of the parent trunk and from the collaterals renders this one of the most formidable operations of surgery, and, after Syme, with the exception of Annandale, few surgeons have practised it extensively.

INTRA-SACULAR LIGATION.—This method, which was elaborated by Syme (1861) and Annandale (1885), is especially adapted to recent traumatic aneurysms in which a complete adventitious sac has not developed. The circulation having been controlled by a Petit's tourniquet, the aneurysm is opened up, the clots removed, and a bougie passed into each end of the parent trunk. A small incision is then made through the floor of the sac on each side of the proximal orifice to admit of a ligature being passed round the vessel, and as this is tightened up the bougie is withdrawn. This manœuvre is repeated at the distal end, and at any collateral branch that may require it. This method was adopted with remarkable success by Kikuzi and other Japanese surgeons during the Russo-Japanese war. To admit of an efficient collateral circulation being established before the main vessel is ligated, the operation should not be performed till about six weeks

after the accident, if other circumstances permit of the delay.

**Operation for Aneurysmal Varix.**—The circulation is controlled by a Petit's tourniquet, the varix exposed by dissection, and the communication between the artery and the vein cut across. The opening in the vein is then closed by a fine continuous catgut or silk suture

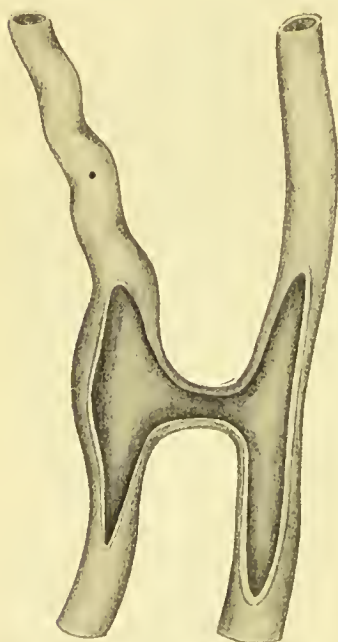


FIG. 8.—Diagram of Aneurysmal Varix.

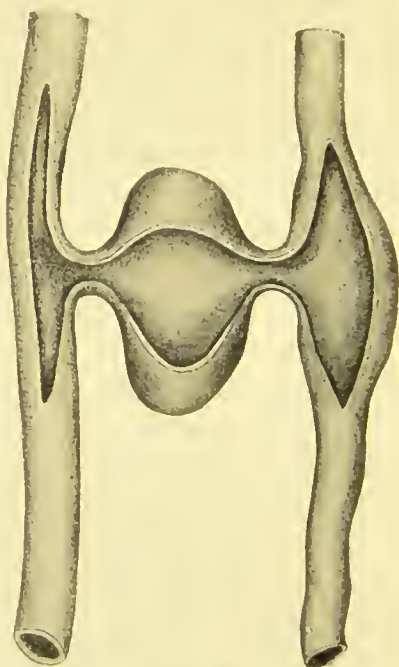


FIG. 9.—Diagram of Varicose Aneurysm.

carried through all the coats; and that in the artery by lateral arteriorrhaphy.

**Operation for Varicose Aneurysm.**—If it is possible, Matas' reconstructive procedure should be adopted, as it not only offers the prospect of conserving the patency of the artery and vein, but ensures that any collateral branch leaving the aneurysm shall be dealt with.

If this operation does not effectively control the circulation through the aneurysm, the artery must be

ligated above and below the point of communication, the sac incised and emptied of clots, and any collateral branches secured by ligature. If it can be avoided, the vein should not be ligated.

REVERSAL OF THE PERIPHERAL CIRCULATION.—*End-to-end Anastomosis of an Artery and Vein.*—The experimental work of Carrel, Morel, and Guthrie has shown that it is possible to reverse the peripheral circulation in a limb by dividing the main artery and its accompanying vein, and uniting the proximal end of the artery to the distal end of the vein, and *vice versa*—the proximal end of the vein to the distal end of the artery. The arterial blood is in this way directed into the vein, and is carried by the tributaries to the capillaries, from which the venous blood is collected by the smaller branches of the arteries and carried to the main trunk as far as the seat of anastomosis, where it regains the venous current.

This procedure has been employed with a view to improving the blood supply in cases of threatened or commencing gangrene of the extremities associated with arterial sclerosis. The results hitherto obtained, however, have only been partly successful. If the veins are thrombosed the operation is useless.

The technique is the same as in circular arteriorrhaphy. This operation is much easier and apparently equally efficient if the distal end of the artery and the proximal end of the vein are ligated, and the proximal end of the artery is joined to the distal segment of the vein.

The operation has been most frequently performed as a prophylactic measure in cases in which, as a result of arterial sclerosis, there is threatening gangrene in the lower extremity.

An oblique incision is made from above downwards and inwards, with its centre at the apex of the femoral, or Scarpa's triangle. The superficial femoral artery and

vein are exposed for a distance of at least two inches. The artery is clamped at the highest point exposed, and the vein at the lowest point exposed. We have found a light intestinal clamp preferable to that devised by Crile, as the handle is of great assistance in exposing the different parts of the circumference of the vessels. The artery is cut across at the most distal part exposed, the sheath of the vessel stripped for about half an inch from the cut edge, any clot in its interior removed, and the intima smeared with vaseline. One or

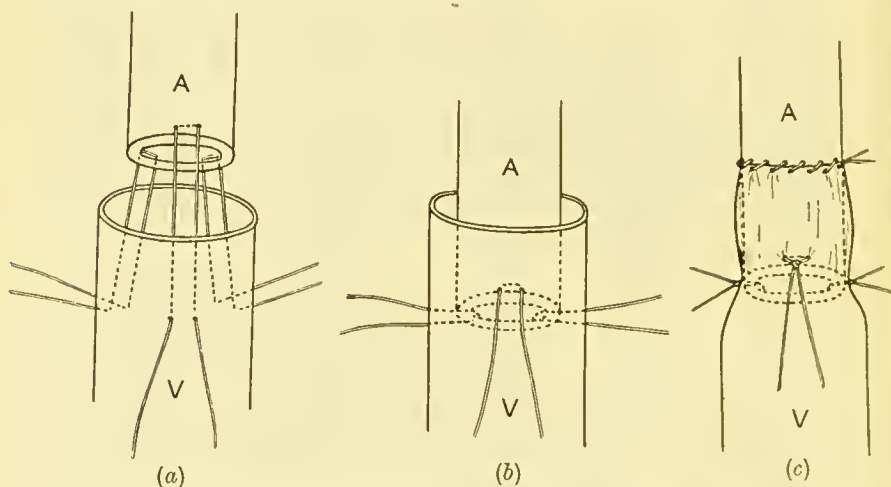


FIG. 10.—Diagram to illustrate Method of uniting Artery to Vein, in reversal of Peripheral Circulation. (After F. F. Burghard.)

two mattress sutures, which do not penetrate the lining membrane of the artery, are then inserted, the two ends of each suture are carried into the lumen of the vein, and brought out through all its coats half an inch beyond the cut edge (Fig. 10). When these sutures are pulled upon, the artery is invaginated into the interior of the vein. They are knotted and tied, and the junction is completed by a continuous suture at the extreme point of overlapping. The clamps are then removed, and if there is any leakage an additional suture is inserted.

LIGATION OF ARTERIES IN THEIR  
CONTINUITY

Arteries may be ligated in their continuity in the treatment of aneurysm and of pulsating tumours, for example in the orbit, or as a preliminary to certain operations, such as excision of the tongue, or amputation at the hip-joint, with a view to preventing hæmorrhage. Sometimes the operation is performed to control the growth of malignant tumours or to arrest hæmorrhage from these. In the treatment of secondary hæmorrhage it is not often called for at the present day. Since operations have come to be performed under aseptic conditions, ligation of large arteries is comparatively seldom followed by secondary hæmorrhage or gangrene. Even when both the main artery and vein are tied, gangrene does not necessarily supervene so long as infection is excluded. The more direct means of treating aneurysm now in vogue has diminished the frequency with which ligation is performed.

**Incision and Exposure of the Artery.**—As a general rule the incision is made in the line of the artery, but in some cases, for example, in ligation of the femoral at the base of the femoral (Scarpa's) triangle, better access is obtained by making the incision across the course of the vessel, as is recommended by Kocher. In certain deeply placed arteries, for example the posterior tibial, the incision is made so as to reach the vessel by a route which affords direct access and involves the minimum disturbance of anatomical structures. The length of the incision varies with the size of the artery, the complication of its anatomical relations, and its depth from the surface. In fat or very muscular subjects the length of incision must be materially increased.

The knife should be held like a dinner knife, and the skin cut at right angles to the surface, so that it is not



bevelled or under-cut. The primary incision is carried right down to the deep fascia, and each layer should be divided to the same extent as the skin, and no more.

The deeper dissection should be carried out through the intermuscular septa, which are usually indicated by a thin layer of fat through which small blood vessels emerge. In the cadaver, as the intermuscular septa are more difficult to identify, the dissection is apt to be carried through the substance of the muscle. The individual muscles are separated from one another by blunt dissection and held aside by retractors, care being taken that the two sides of the wound are equally retracted, otherwise it is easy to leave the track of the artery. In the living subject the artery is identified by its pulsation and by the firm, elastic feel of its wall. The vein as a rule is much larger than the companion artery, and often overlaps it. It is recognised by its blue colour, its thin wall, and the ease with which it can be compressed. In the cadaver, if the artery is not injected, it is recognised by its greyish-white colour and collapsed anterior wall, which forms a deep groove. The vein, being empty and collapsed, is less evident than the artery.

The artery having been exposed, a portion is cleared sufficiently to allow of the aneurysm needle being passed round it without force, and without risk of perforating the companion vein or of including neighbouring structures, such as the vein or an adjacent nerve or tendon. In those arteries that are accompanied by *venæ comites* it is often best to include the veins with the artery rather than to carry out a dissection to separate them, as this often leads to troublesome bleeding from the cross branches which are inevitably divided.

In larger trunks, such as those above the popliteal and the brachial, where the artery has a separate sheath

and is accompanied by a single vein, the sheath should be deliberately opened with the knife and the artery cleared for a distance of about a quarter of an inch.

The needle is preferably passed unthreaded, and from the side of the artery on which the more important structures lie. Where there is a single large vein accompanying the artery the needle is passed from the side on which the vein lies. Where there are *venæ comites* the presence of a nerve trunk on one or other side will determine the direction in which the needle is to be passed.

**The Ligature.**—The most suitable ligature materials are chromicised catgut, kangaroo tendon, and fine Chinese twist silk.

In large vessels, as for example the femoral, axillary, or common carotid, in which the vessel wall in the region of the ligature will have to bear the strain of a high arterial pressure, it is better merely to obliterate the lumen without rupturing any of the coats (Ballance and Edmunds). In smaller vessels no harm results from rupturing the inner and middle coats. For the purpose of obliterating the lumen of the vessel, without rupturing its walls, the *stay knot* is employed. This consists of two ligatures applied side by side, each having the first turn of a reef knot tied separately. The two ends on each side are then used as a single cord with which to make a second turn of the reef knot.

The chief dangers at this stage of the operation are the inclusion of other structures within the ligature and wounding of the vein. To avoid these, the needle should be passed in a direction away from the vein, and its point should be kept in close contact with the artery. If the vein is punctured, bleeding may be arrested by a lateral ligature or by a close continuous suture of fine silk or catgut, introduced with a round intestinal needle.

In the **after-treatment** precautions must be taken to

diminish the risk of gangrene of the limb. The whole limb is purified, wrapt in absorbent cotton-wool and lightly bandaged, and elevated sufficiently to promote the venous return without at the same time impeding the arterial flow. The limb should be kept at absolute rest for at least three weeks.



## CHAPTER II

### LIGATION OF ARTERIES OF NECK

INNOMINATE (ANONYMA). SUBCLAVIAN. INTERNAL MAMMARY  
BRANCH OF SUBCLAVIAN. COMMON CAROTID—At Seat of  
Election, below Omo-hyoid. EXTERNAL CAROTID. INTERNAL  
CAROTID. FACIAL—At origin, on Face. LINGUAL—At origin,  
beneath Hyoglossus. VERTEBRAL.

LIGATION OF THE INNOMINATE ARTERY (ARTERIA ANONYMA).  
—The innominate artery arises from the convexity of  
the arch of the aorta behind the middle of the lower  
part of the manubrium sterni, and terminates opposite  
the right sterno-clavicular joint between the two heads of  
the sterno-mastoid by dividing into the right subclavian  
and right common carotid. The course of the artery is  
indicated by a line drawn from a point slightly to the  
right of the middle of the lower part of the manubrium  
to the right sterno-clavicular joint. The vessel can be  
felt pulsating in the episternal notch. It gives off no  
branches except an inconstant thyroidea ima, which passes  
up in front of the trachea and gives branches to the  
lateral lobes and isthmus of the thyroid gland and to the  
trachea.

The operation has been performed for aneurysm of  
the first part of the right common carotid and of the first  
and second parts of the right subclavian. To expose  
the artery, an incision is made through the skin and  
fascia from the junction of the middle and lower thirds  
of the anterior border of the right sterno-mastoid to  
the anterior surface of the manubrium sterni. The

sternal origin of the sterno-mastoid is then separated from the sternum, and the outer border of the sternal attachments of the sterno-hyoid and sterno-thyroid, together with the branches of the descendens hypoglossi nerve, are pulled inwards, care being taken to avoid the transverse vein connecting the two anterior jugular veins, and the terminal portion of the anterior jugular vein behind the origin of the sterno-mastoid. It is sometimes necessary to resect the inner end of the clavicle and the upper part of the sternum to obtain sufficient access.

The second layer of fascia is then divided, and the right common carotid identified and traced down to the innominate. The right inferior thyroid vein is ligated and cut across. The left innominate vein lies in front of the lower part of the artery, the trachea and right pleura lie behind it; the right innominate vein and upper part of the superior vena cava are on its right side and the left common carotid on its left side. The vagus, recurrent laryngeal, and phrenic nerves lie to its outer side, but are not in immediate danger.

The ligature is applied close to the bifurcation, the needle being passed from right to left to avoid the pleura and right innominate vein.

*Collateral Circulation.*—After ligation of the innominate, the blood is carried to the head and neck by the carotid and vertebral arteries of the opposite side. The two internal carotids and vertebrals communicate through the *circulus arteriosus Willisii* (circle of Willis); and the branches of the external carotids anastomose across the middle line in the neck and face. The collateral circulation to the arm is chiefly established through the *intercostal anastomosis*; the superior intercostal branch of the subclavian (*truncus costo-cervicalis*) communicating with the lateral branches of the aortic intercostals and the intercostal branches of the internal mammary, and those in turn with the thoracic and subscapular branches of the

axillary. The superior epigastric branch of the internal mammary communicates with the inferior (deep) epigastric branch of the external iliac.

LIGATION OF THE SUBCLAVIAN ARTERY.—*Third part.* (Fig. 11).—The origin of the subclavian, the main artery of supply to the upper extremity, differs on the two sides. On the left side the vessel arises directly from the arch of the aorta behind the lower part of the manubrium sterni, and on the right at the bifurcation of the innominate artery opposite the right sterno-clavicular joint. The course of the artery at the root of the neck is indicated by a line from the sterno-clavicular articulation to the middle of the clavicle, reaching up into the neck for a distance of half an inch to one inch above the clavicle.

The first and second parts of the artery are never selected for ligation in the living subject, but if the third part is found to be diseased the scalenus anterior may be notched to afford access to the second part. As the phrenic nerve has left the muscle at this level, it is not endangered (John Chiene). The third part may be ligated for axillary aneurysm, for primary or secondary hæmorrhage from the axillary artery, as a distal operation in innominate or aortic aneurysm, or as a preliminary to removal of the arm and scapula. This part is the most superficial, and lies in the triangle formed by the clavicle, the omo-hyoid, and the outer edge of the scalenus anterior. Normally no branches arise from this part of the artery.

The patient is brought close to the edge of the table with the head inclined to the opposite side, and, to depress the clavicle, the arm is drawn down and kept in contact with the side. An incision is made from a point over the clavicular portion of the sternomastoid to the anterior border of the trapezius, parallel with the clavicle and a finger's breadth above it.

In making the incision it is an advantage to pull down the skin so that it can be cut against the bone; in this way injury to the external jugular vein is

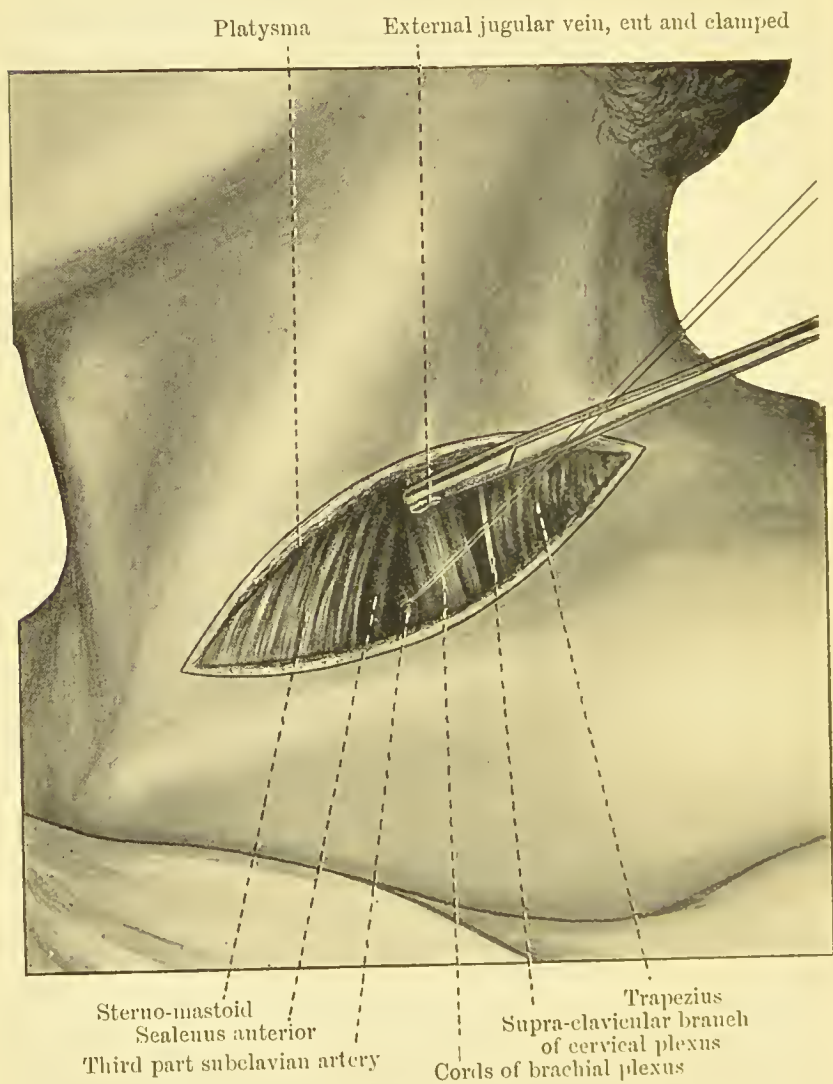


FIG. 11.—Ligation of Third Part of Left Subclavian Artery.

avoided, as it pierces the fascia a short distance above the clavicle and therefore cannot be pulled down with the skin. The incision divides the integument, in-

cluding the platysma, and the supra-clavicular branches of the descending superficial cervical nerves. The external jugular vein, sometimes represented by a plexus of tributary veins, is seen crossing the sternomastoid to pierce the deep fascia at its posterior border. If it cannot be held aside it should be clamped between two forceps and cut across, because if opened without being clamped it is kept patent by the deep fascia, and air is apt to be sucked in during inspiration (air embolism).

The deep fascia is now divided in the same direction as the skin, and at the outer angle of the wound the omo-hyoid is exposed passing upwards and inwards. In the fatty tissue are several lymph glands, and the transversalis colli artery and its superficial cervical branch cross the upper part of the wound, while the supra-scapular (transverse scapular) runs outwards behind the clavicle. All these vessels are to be carefully preserved, as they take part in the establishment of the collateral circulation. After the fatty tissue has been removed, the cords of the brachial plexus are seen running almost vertically downwards to disappear under the clavicle, and the subclavian artery is found alongside the inner cord of the plexus. This is the most constant and reliable guide to the artery. The omo-hyoid having been retracted, the outer edge of the scalenus anterior is defined by dividing the fascia proceeding from it, and is traced down to the scalene tubercle of Lisfranc on the first rib. The subclavian artery emerges from behind the muscle and rests against the dome of the pleura, the scalenus medius, and the first rib.

Internal to the scalenus anterior is the bulbous portion of the internal jugular vein, and in front of the subclavian artery and separated from it by the scalenus anterior is the subclavian vein. The phrenic



nerve, having already left the muscle, is not endangered. On the left side, the thoracic duct ascends from the chest into the neck close to the inner border of the scalenus anterior and passes into the angle between the subclavian and internal jugular veins. When present, the right lymphatic duct lies along the inner border of the right scalenus anterior.

The needle should be passed away from the brachial plexus—that is, from above and behind, its point being guided with the left forefinger, which protects the vein and pleura.

*Collateral Circulation.*—After ligation of the third part of the subclavian, the collateral circulation is established through the intercostal anastomosis (p. 18), and the *scapular anastomosis*, in which the supra - scapular (*arteria transversa scapulæ*) and the posterior scapular derived from the subclavian, communicate with the subscapular branch of the axillary.

**Ligation of the Internal Mammary Artery** (Fig. 12).—The internal mammary branch of the subclavian is most easily reached in the second intercostal space through an incision which passes from the middle line of the sternum, transversely outwards between the costal cartilages. The skin and fascia having been divided, the fibres of the internal intercostal are exposed. These, together with the fascia beneath them, are cut, and the artery, with its *venæ comites*, is seen lying against the pleura, about a quarter to half an inch from the edge of the sternum. If the access is insufficient, a portion of the costal cartilage may be resected.

In passing the needle, great care must be taken not to injure the pleura.

In the lower intercostal spaces, the artery lies a little farther out from the edge of the sternum.

**LIGATION OF THE COMMON CAROTID ARTERY.**—The right common carotid artery commences at the bifurca-

tion of the innominate, opposite the right sterno-clavicular articulation; the left arises directly from the arch of the aorta. Each terminates at the level of the upper border of the thyroid cartilage by dividing into external and internal carotid. For surgical purposes, the intra-thoracic portion of the left artery is negligible. The

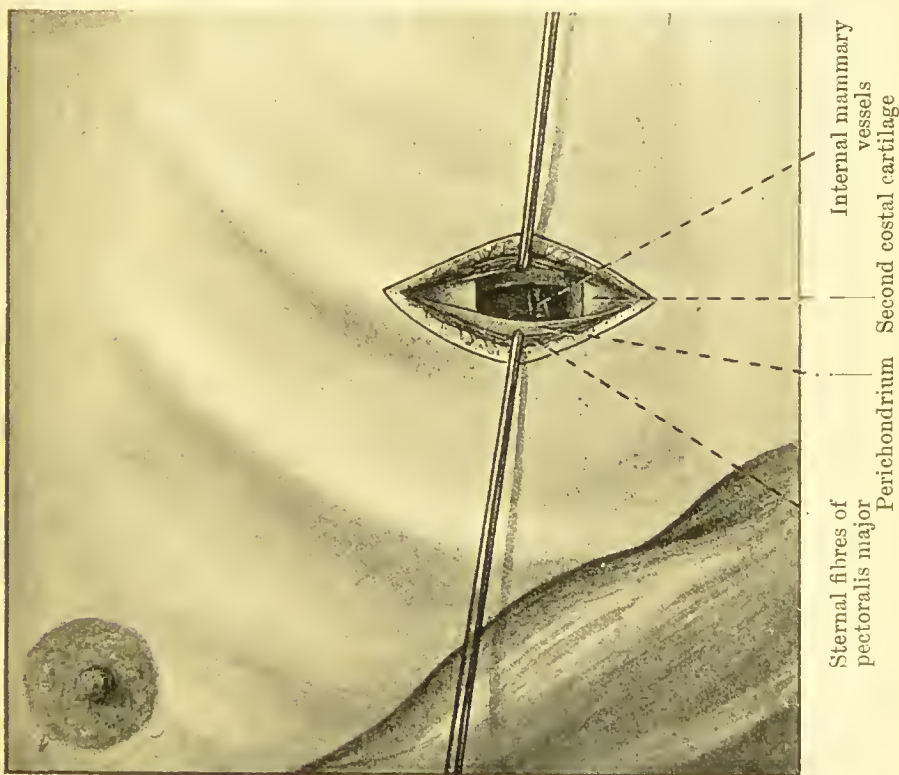


FIG. 12.—Ligation of Right Internal Mammary Artery.

omo-hyoid muscle crosses the artery at the level of the lower border of the cricoid cartilage, and the part above the crossing of the omo-hyoid, although under the deep fascia, is comparatively superficial, and is that usually selected for ligation. It can be felt pulsating in the hollow between the larynx and the anterior border of the sterno-mastoid, which slightly overlaps it. The first

or lower part of the artery is more deeply placed, and is covered by the sterno-thyroid, sterno-hyoid and sterno-mastoid muscles, and it is sometimes overlapped by the lateral lobe of the thyroid gland.

The artery, together with the internal jugular vein and the vagus nerve, is enclosed by a fibrous sheath—the carotid sheath—derived from the cervical fascia. The vessel can be compressed at the level of the cricoid by pressing backwards and inwards against the transverse process (carotid tubercle) of the sixth cervical vertebra. In compressing the artery the vagus also may be pressed upon, and this gives rise to slowing of the pulse, dyspnœa, and syncope.

The course of the common carotid is indicated by a line drawn from the upper end of the sterno-clavicular articulation to a point midway between the tip of the mastoid process and the angle of the jaw, that portion of the line below the upper border of the thyroid cartilage corresponding to the common carotid trunk. The artery gives off no branches.

**Ligation at the Seat of Election**, that is, above the omo-hyoid, may be performed—(1) As a distal operation in innominate or aortic aneurysm, or as a proximal operation for aneurysm at the bifurcation or of the internal carotid. (2) For hæmorrhage from wounds or ulceration of the artery itself, or in the distribution of the internal carotid. (3) As a preliminary to operations upon malignant tumours in the upper part of the neck or in the head, either as a temporary or a permanent occlusion. (4) The artery has been ligated in cases of hydrocephalus and for epilepsy, first on one side and later on the other.

The common carotid should never be tied if ligation of the external carotid will serve the purpose, because of the liability to anæmia of the brain centres on the same side. In about 20 per cent. of cases of ligation



of the common carotid in persons above middle life, the operation is followed by hemiplegia and unconsciousness, and eventually proves fatal.

An oblique incision is made in the line of cleavage of the skin at the level of the cricoid cartilage, the middle of the incision being at the anterior border of the

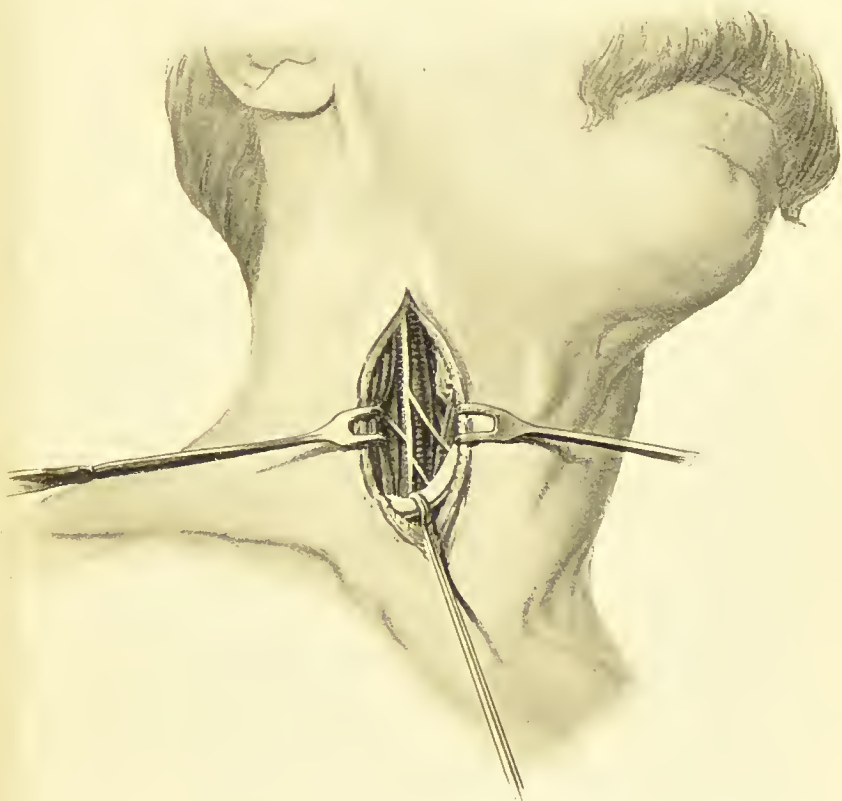


FIG. 13.—Ligature of Right Common Carotid above Omo-hyoid.  
(After F. F. Burghard.)

sterno-mastoid. After the skin and platysma are divided and the superficial vessels secured, the transverse superficial cervical nerve (*n. cutaneus colli*) is seen passing forwards over the sterno-mastoid from its posterior border and is hooked aside. The deep fascia is then divided and

the anterior edge of the sterno-mastoid freely exposed and pulled outwards with a retractor. The sterno-mastoid branch of the superior thyroid artery must be divided. The omo-hyoid is then exposed passing upwards and inwards, and in the angle between these two muscles, the artery is sought for after dividing the deeper layer of the fascia which forms the sheath. On the surface of the sheath is seen the descendens hypoglossi nerve which supplies the depressor muscles of the hyoid, the branches to which pass forwards. The nerve, therefore, should be drawn inwards.

The internal jugular vein lies to the outer side of the artery, and in the living subject overlaps it to a variable extent.

The vagus nerve, which occupies the third compartment of the sheath, lies behind and between the artery and vein; behind the sheath is the sympathetic cord. The vessel rests against the prevertebral fascia and the vertebral muscles. To the inner side lie the trachea and larynx and the gullet, with the recurrent laryngeal nerve in the groove between them. The gullet has a less intimate connection with the right than with the left common carotid.

The needle is passed from without inwards and is kept close to the artery to avoid including the vagus; it is better to see the nerve to make certain of this.

**Ligation below the Omo-hyoid.**—The artery lies much deeper and the operation is more difficult, especially in short-necked persons. The incision is made obliquely across the neck a short distance above the clavicle, dividing the deep fascia (Fig. 14). The sterno-mastoid is exposed and pulled outwards, and the sterno-hyoid and thyroid are drawn inwards or divided. The sheath, having been exposed, is opened, and the vein is found to the outer side of the artery. On the left side the vein overlaps the artery to a greater extent than on the right.

LIGATION OF THE EXTERNAL CAROTID ARTERY.—The external carotid is the smaller of the two branches of the common carotid, and extends from a point opposite the upper border of the thyroid cartilage to the level of the neck of the lower jaw, where it divides into the

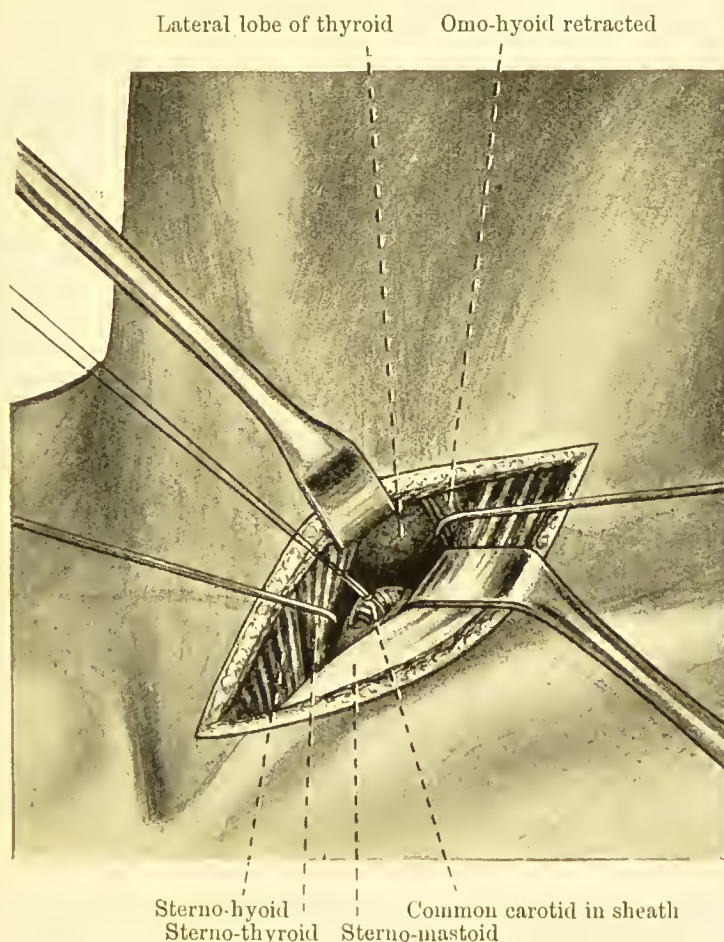


FIG. 14.—Ligation of Left Common Carotid below Omo-hyoid.

superficial temporal and the internal maxillary, either under cover of, or in the substance of, the parotid gland. At first it lies a little in front and to the inner side of the internal carotid and then passes backwards and comes to be superficial to it. At its origin, the vessel

is comparatively superficial, being overlapped only by the sterno-mastoid. As it ascends, it passes backwards and becomes deeper, and giving off a number of branches, it rapidly becomes smaller. Below the digastric it is

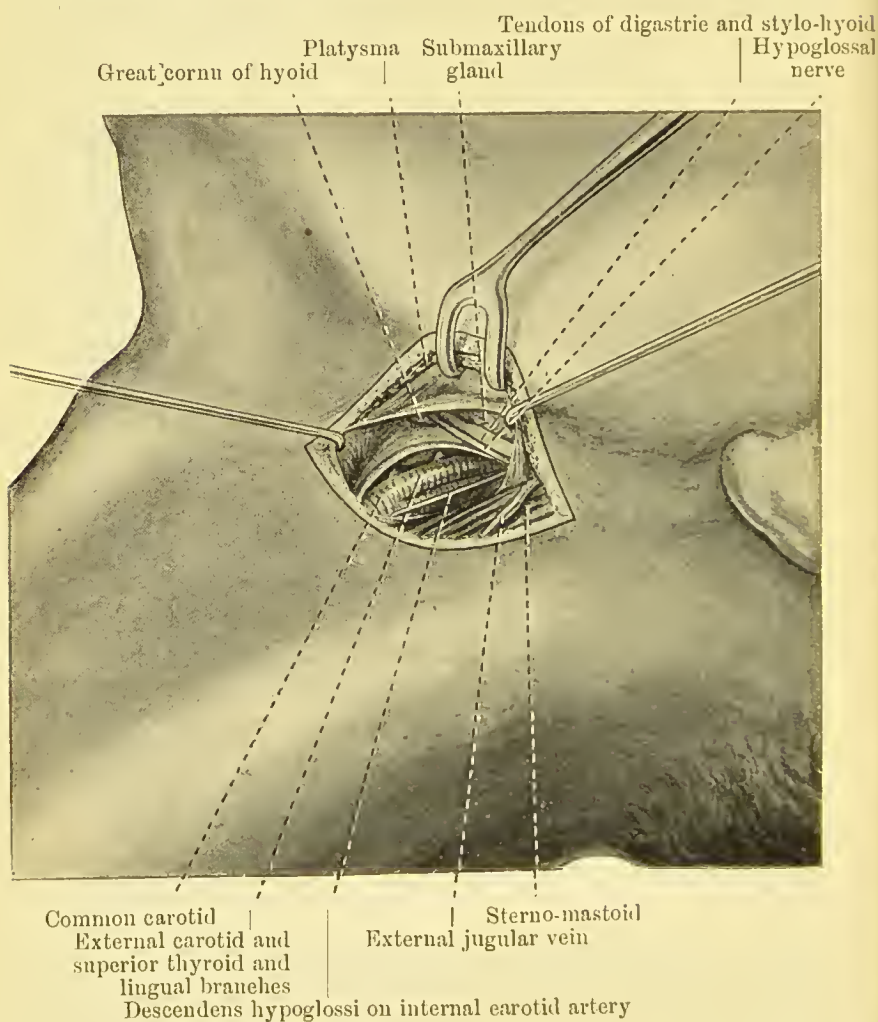


FIG. 15.—Ligation of Left External Carotid Artery.

crossed by the hypoglossal nerve, and usually by the lingual and facial veins. Above the digastric it is crossed by the inframaxillary branch (ramus colli) of the facial nerve. The superior laryngeal nerve passes



immediately behind the vessel near its origin. Its branches are: the superior thyroid, lingual, facial (external maxillary), occipital, posterior-auricular, and ascending pharyngeal.

The course of the vessel is indicated on the surface in the same way as that of the common carotid. To expose the artery, an oblique incision is made a finger's breadth below the angle of the jaw, dividing the skin and platysma, the latter of which may be so well developed as to be mistaken for the sterno-mastoid (Fig. 15).

At the posterior part of the wound, the external jugular vein is exposed, and behind it the great auricular nerve, both running vertically over the sterno-mastoid. These structures are drawn backwards. The anterior edge of the sterno-mastoid is exposed by dividing the deep fascia.

In the upper part of the wound the digastric muscle is seen with the hypoglossal nerve below it. These are displaced upwards, and the artery is exposed.

The ligature is applied between the superior thyroid and the lingual branches, exactly opposite the great cornu of the hyoid bone, the needle being passed from without inwards.

**LIGATION OF THE INTERNAL CAROTID ARTERY.**—The internal carotid extends from the bifurcation to the carotid canal in the petrous temporal bone. It lies deeper than, and a little posterior to, the external carotid, against the lateral wall of the pharynx.

It is rarely tied. The operation is carried out on the same lines as that for ligation of the external carotid, which is exposed in the first instance. The needle is passed from the outer side, care being taken to avoid injuring the jugular vein, the vagus nerve, or the sympathetic cord.

**Ligation of the Facial (External Maxillary) Artery.**—

*At its origin*, the facial artery may be tied by an operation similar to that for ligation of the external carotid.

*On the face*, it is secured as it crosses the lower border of the jaw just in front of the masseter muscle. An incision is made immediately below and parallel with the lower border of the jaw opposite the anterior edge of

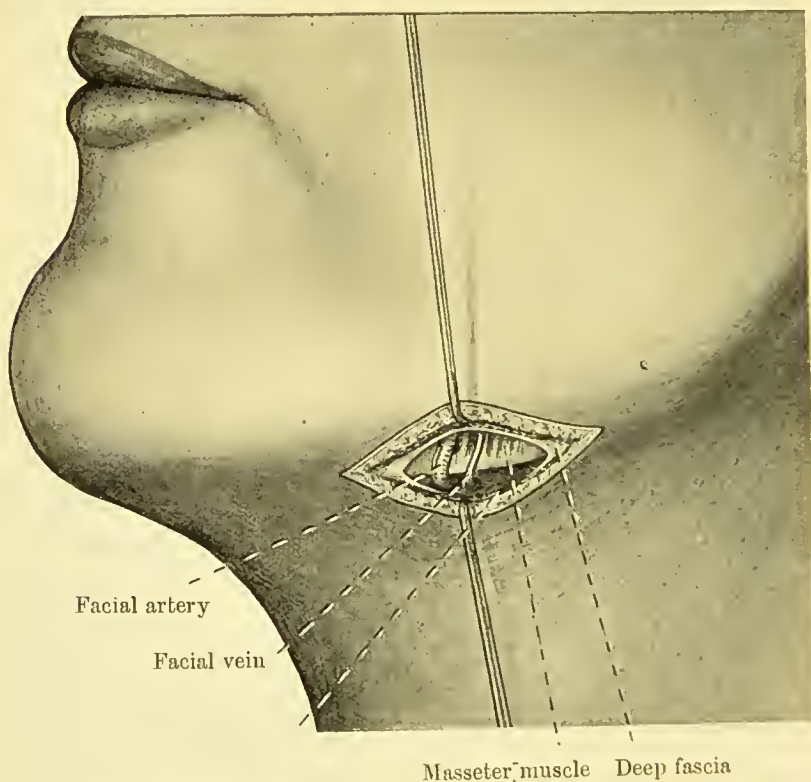


FIG. 16.—Ligation of Left Facial (External Maxillary) Artery.

the masseter muscle, care being taken to avoid injuring the supra-mandibular (marginal) branch of the facial nerve which runs above the margin of the jaw. The artery, with the vein behind it, is exposed after dividing the integument and platysma, and is easily secured (Fig. 16).

**Ligation of the Lingual Artery.**—The operation for ligation of the lingual artery *at its origin* is the same as that for ligation of the external carotid.

*In its second part*—beneath the hyoglossus—it is reached by a curved incision following the line of the hyoid bone, commencing at the anterior edge of the sterno-mastoid and passing along the greater cornu of the hyoid bone as far as its body (Fig. 17). The integument,

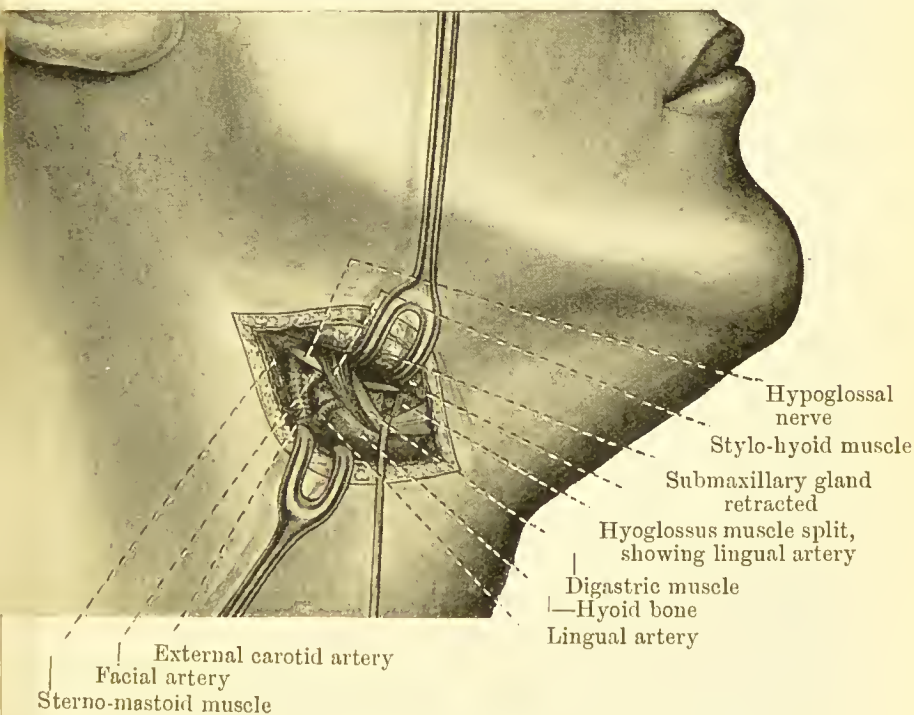


FIG. 17.—Ligation of the Right Lingual Artery in its second part.

including the platysma, is divided, the branches of the anterior jugular and facial veins are secured and divided, and the deep fascia is incised in a line parallel with the upper border of the hyoid bone. The submaxillary gland thus exposed is retracted upwards, along with the integument. If the hyoid bone is now pressed forwards from the opposite side of the neck and seized



with a hook, the digastric and stylo-hyoid muscles are made prominent, and the hypoglossal nerve, with the ranine vein just below it, is identified as it crosses the surface of the hyoglossus, which is recognised by the vertical direction of its fibres. The hypoglossal nerve and the ranine vein having been drawn upwards, the hyoglossus is cut close to and parallel with the hyoid bone or split vertically. The artery, which usually bulges out through the divided muscle fibres, is cleared sufficiently to enable a ligature to be passed round it. The wound is then closed after replacing the submaxillary gland and the skin flap.

**Ligation of the Inferior Thyroid Artery.**—The inferior thyroid, the most important branch of the thyroid axis, is exposed through a transverse incision in the lower third of the neck, extending from the edge of the sterno-mastoid to the middle line. After the skin, platysma, and deep fascia have been divided, the sterno-mastoid pulled outwards, and the sterno-thyroid inwards, the carotid artery is exposed in the outer part of the wound and the thyroid gland in the inner part. The carotid sheath and its contents are pulled outwards and the inferior thyroid is exposed behind them. In passing the aneurysm needle, care must be taken to avoid the recurrent laryngeal nerve which crosses behind the bend of the artery and ascends upon the longus colli muscle.

**Ligation of the Vertebral Artery.**—This vessel is rarely ligated in the living subject. It arises from the upper and back part of the first portion of the sub-clavian, and runs upwards in the space between the inner border of the scalenus anterior and the outer border of the longus colli as far as the foramen in the transverse process of the sixth cervical vertebra, which it enters. Near its origin it is crossed by the anterior jugular and vertebral veins and by the inferior thyroid artery, and on the left side by the thoracic duct. The

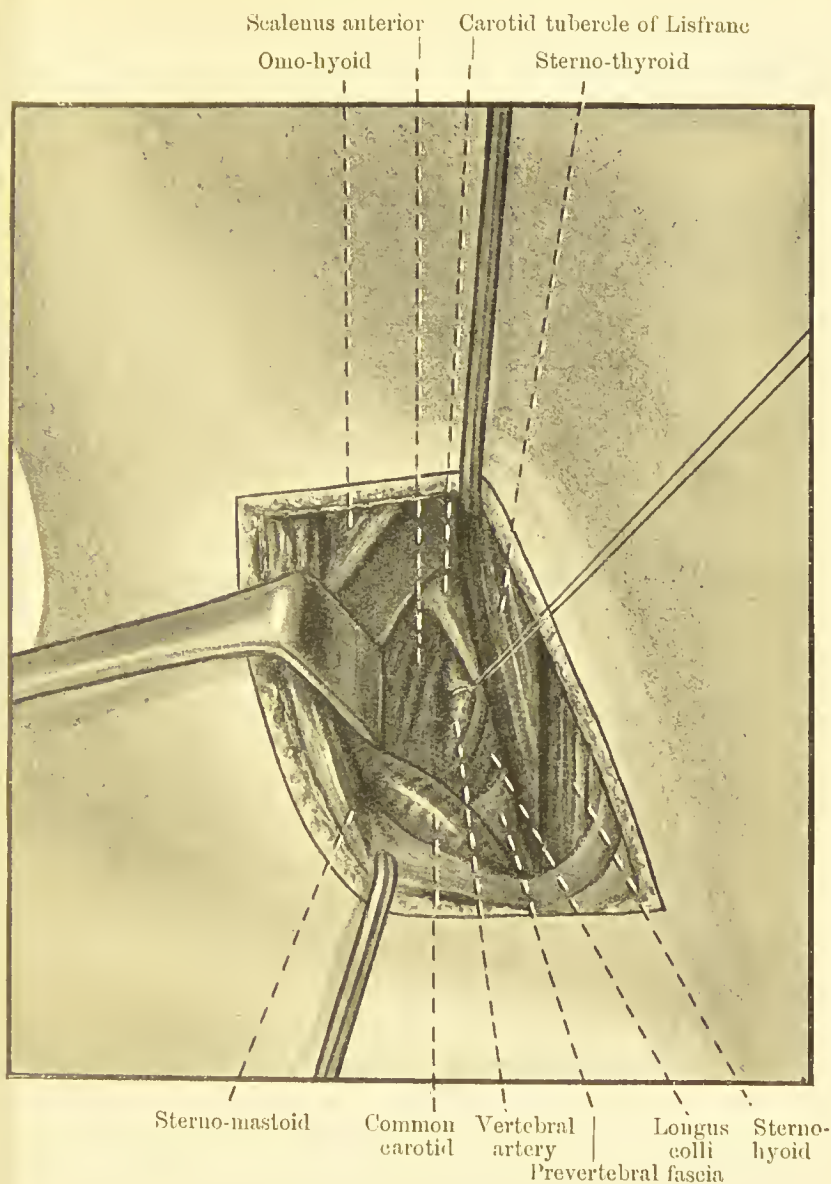


FIG. 18.—Ligation of Right Vertebral Artery.

best guide to the vessel is the carotid tubercle, and throughout the operation this landmark should never be lost sight of.

The artery is exposed through an oblique incision

beginning above the supra-sternal notch, and passing upwards and outwards over the sterno-mastoid (Fig. 18). After division of the skin and platysma, the anterior edge of the sterno-mastoid is exposed and the muscle drawn well outwards. The omo-hyoid is drawn upwards and the sterno-hyoid inwards. The common carotid, the internal jugular, and the vagus are drawn outwards in the carotid sheath. The inner aspect of the sheath is then cleared, and the dissection carried down between the sheath and the thyroid gland. The recurrent laryngeal nerve, passing upwards alongside the trachea, must be avoided. The prevertebral fascia is incised from the level of the carotid tubercle to the arch of the inferior thyroid artery, and the vertebral artery is found under cover of the outer edge of the longus colli. The scalenus anterior, on which lies the phrenic nerve, is at its outer side.

The ligature may be passed in either direction, but care must be taken to avoid including the fibres of the sympathetic, which surround the artery.

## CHAPTER III

### LIGATION OF THE ARTERIES OF THE UPPER EXTREMITY

AXILLARY: First Part—Second Part—Third Part. BRACHIAL: In Middle of Upper Arm—At Bend of Elbow. RADIAL: Upper Third—Middle Third—Lower Third—On Back of Wrist. ULNAR: Above Origin of Common Interosseous—In Middle of Forearm—In Lower Third.

LIGATION OF THE AXILLARY ARTERY.—With the arm abducted to a right angle with the trunk, the course of the axillary artery is indicated on the surface by a line drawn from a point a little outside the middle of the clavicle to a point on the inner border of the coraco-brachialis opposite the level of the lower border of the teres major. The pectoralis minor crosses the artery, dividing it into three parts. The upper edge of the pectoralis minor is indicated by a line drawn from the upper border of the third costo-chondral junction to the coracoid process, and its lower edge by a line drawn from the lower border of the fifth rib to the coracoid.

The *indications* for ligation of the axillary artery are: wounds of the artery itself; uncontrollable hæmorrhage from vessels beyond; aneurysm of the brachial (proximal operation); and aneurysm of the subclavian (distal operation).

The *collateral circulation* is established by the same anastomosis as after ligation of the third part of the subclavian.

Clavicular origin of pectoralis major (partly divided)

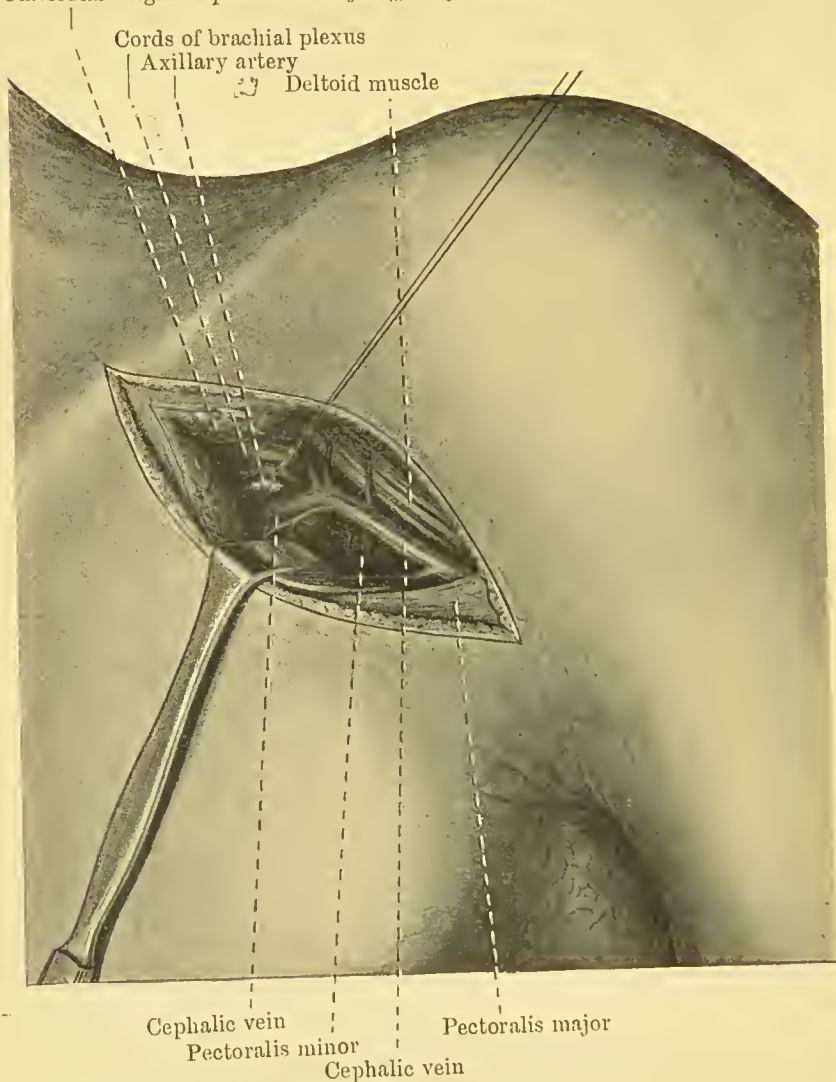


FIG. 19.—Ligation of First Part of Left Axillary Artery.

**Ligation of the First Part of the Axillary Artery.**—When the arm is close to the side, about an inch of the vessel lies above the pectoralis minor, but in the abducted position the pectoral rises to the level of the first rib and very little of the artery is accessible. The superior



thoracic and sometimes the thoraco-acromial branches arise from the first part.

The vessel may be exposed either (1) by a *transverse curved incision*, with its convexity downwards, about a finger's breadth below the clavicle, extending from a point half an inch outside the sterno-clavicular articulation to a point half an inch internal to the coracoid; or (2) by a *longitudinal incision* (Kocher) beginning over the junction of the outer and middle thirds of the clavicle, and passing down over the coracoid process and along the groove between the deltoid and the clavicular fibres of the pectoralis major (Fig. 19).

With the arm close to the side, the integument, including the platysma, is divided, and the deep fascia opened, care being taken to avoid the cephalic vein, which lies at the edge of the deltoid, and the muscles are separated as far down as the upper edge of the tendon of the pectoralis major. To obtain free access, a portion of the pectoralis major may be divided. The pectoralis minor is then defined and drawn down, and the costo-coracoid membrane divided in the line of the artery immediately to the inner side of the coracoid process. This membrane is pierced by the cephalic vein, the thoraco-acromial artery and vein, and branches of the external anterior thoracic nerve, and these structures must not be injured.

Above and to the outer side of the artery are the outer and posterior cords of the brachial plexus, and the external anterior thoracic nerve. The axillary vein, to which the cephalic vein is a useful guide, lies to the inner side of the artery, the internal anterior thoracic nerve intervening. The vessel lies against the first digitation of the serratus magnus and the contents of the first intercostal space, and has behind it the inner cord of the brachial plexus and the long thoracic or nerve of Bell.

The axillary sheath having been cleared from a portion of the vessel, the needle is passed from within outwards to avoid damaging the vein, and the instrument should be kept in close contact with the artery, lest one or other of the nerve cords be included.

The **Second Part of the Axillary**, lying under cover of the pectoralis minor, measures about an inch and a quarter, and usually gives off the thoraco-acromial, long (lateral), and alar thoracic branches. It is surrounded by the cords of the plexus, the inner of which separates it from the vein.

**Ligation of the Third Part of the Axillary** is the operation of choice in the living subject. About three inches of the vessel are available beyond the lower border of the pectoralis major, where the vessel is covered only by integument and deep fascia. This portion of the vessel gives off the subscapular and the anterior and posterior circumflex branches.

With the arm abducted to a right angle, an incision is made in the line of the vessel along the inner edge of the coraco-brachialis. The integument and axillary fascia having been divided, the coraco-brachialis is exposed and together with the musculo-cutaneous nerve, which may be seen entering it, is drawn outwards. External to the artery lies the median nerve, which may be recognised by its two heads embracing the artery. The axillary vein, the direct continuation of the basilic, lies internal to the artery, but is separated from it by the ulnar nerve and the internal cutaneous nerve of the forearm. The lower part of the artery is sometimes accompanied by venæ comites, continued upwards from the brachial. The artery rests against the muscles inserted into the bicipital (inter-tubercular) groove, and the circumflex axillary and musculo-spiral (radial) nerves.

The vessel having been cleared by dissection, the needle is passed from within outward.



If the ligature is applied near the termination of the artery, the anastomosis will be between the subseapular, lateral thoracic, branches of the axillary and the posterior and anterior circumflex branches of the brachial.

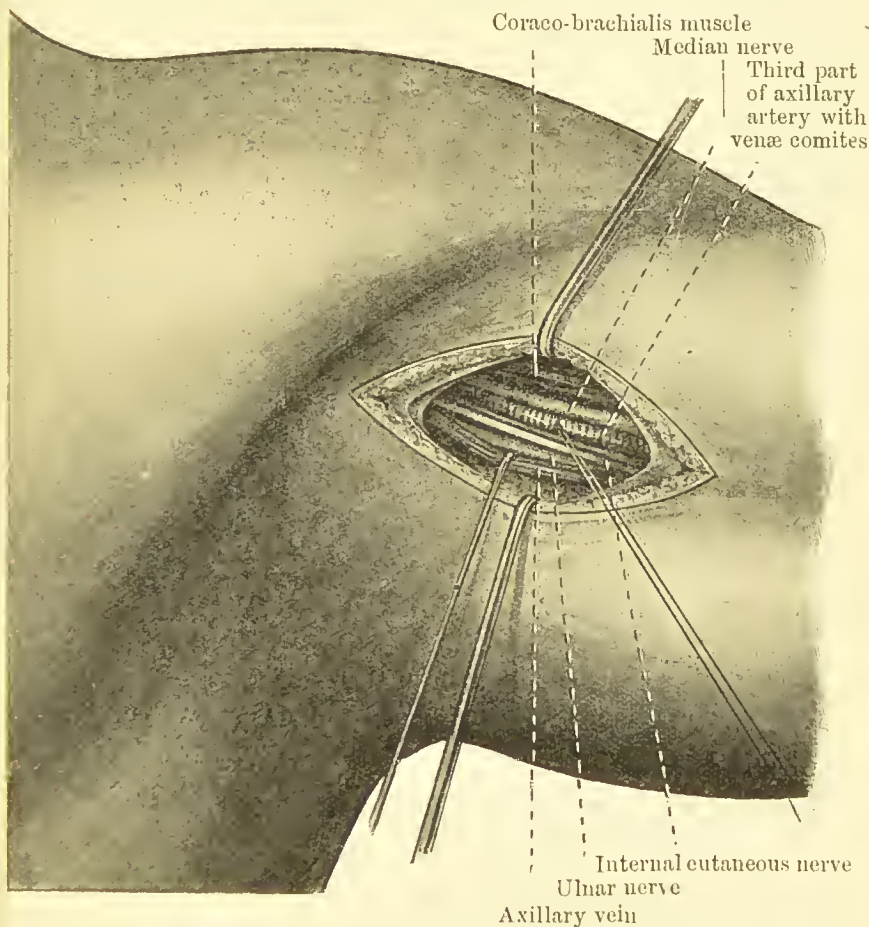


FIG. 20.—Ligation of Third Part of Left Axillary Artery.

The **Posterior Circumflex Artery** is exposed in the same way as the circumflex (axillary) nerve (p. 107).

**LIGATION OF THE BRACHIAL ARTERY.**—The brachial artery extends from the lower border of the teres major to a point a finger's breadth below the middle of the bend of the elbow, opposite the neck of the

radius, where it bifurcates into the radial and ulnar. In its upper two-thirds it lies against the inner aspect of the humerus, slightly overlapped by the coraco-brachialis; in its lower third it lies in front of the bone under the inner edge of the biceps. It can be felt

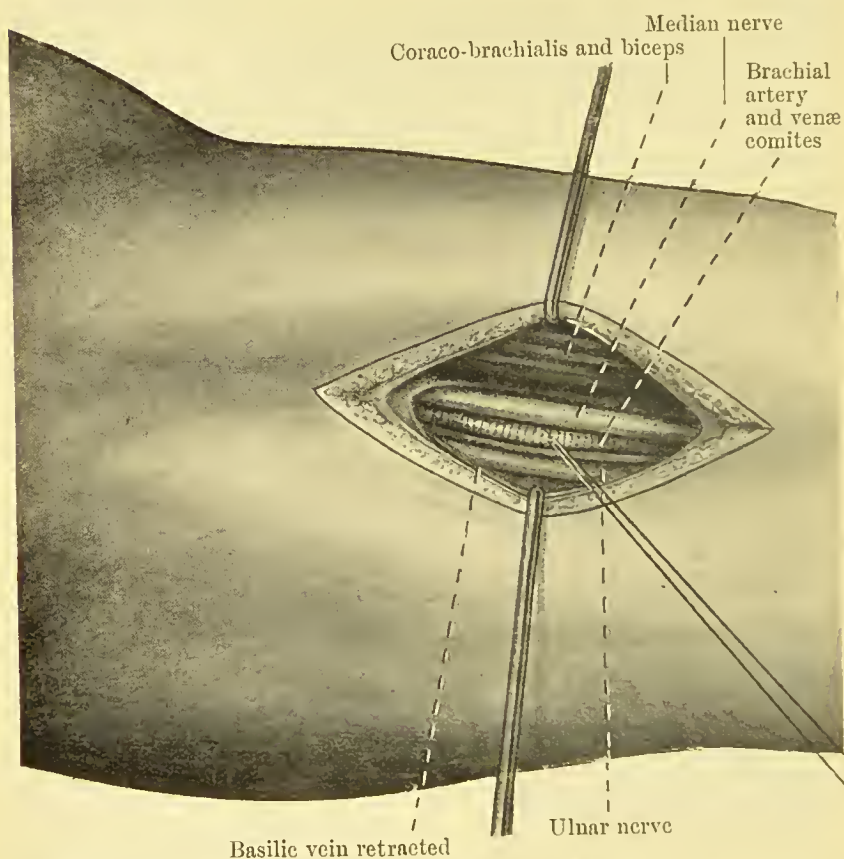


FIG. 21.—Ligation of Left Brachial Artery in Middle of Upper Arm.

pulsating as far as the bend of the elbow, where it passes under the bicipital fascia (lacus fibrosus) and enters the hollow between the pronator teres and the brachioradialis (supinator longus). It is accompanied by two venæ comites. The basilic vein lies to its inner side, superficial to the deep fascia in the lower part and under it in the upper part.

About the middle of the arm the median nerve crosses the artery from without inwards. The ulnar nerve lies to the inner side as far as the insertion of the coraco-brachialis, and then leaves it to pass to the back of the internal epicondyle. The internal cutaneous nerve of the forearm also lies to its inner side until it pierces the deep fascia about the middle of the arm and joins the subcutaneous portion of the basilic vein.

Near its commencement the brachial gives off the superior profunda branch, which accompanies the musculospiral (radial) nerve; lower down the inferior profunda (superior ulnar collateral) arises and accompanies the ulnar nerve; and about two fingers' breadth above its termination it gives off the anastomotic (inferior ulnar collateral) branch, which passes backwards and pierces the internal intermuscular septum.

The chief *indication* for ligation of the brachial in its continuity is secondary hæmorrhage from the vessel itself or in the area of its distribution, particularly in the palm of the hand, where the bleeding-point cannot be secured or the bleeding arrested by pressure.

The vessel may be ligated either at the middle of the upper arm or at the bend of the elbow.

**Ligation of the Brachial Artery at the Middle of the Upper Arm** (Fig. 21).—The limb, abducted to a right angle, is supported by an assistant, because if it is allowed to rest on the table the triceps is pushed forward and obscures the artery; it may even happen that the inferior profunda (superior ulnar collateral) artery and the ulnar nerve are brought into view instead of the brachial artery and the median nerve (Heath). An incision is made in the line of the artery along the inner edge of the biceps, care being taken to avoid the basilic vein. The deep fascia is divided, the edge of the muscle defined and drawn outwards, and the median nerve, thus exposed in front of the artery, drawn aside. To the inner side are the internal cutaneous

and ulnar nerves, the latter lying under the fascia covering the inner head of the triceps. The *venæ comites* are separated from the portion of the artery selected, and the needle is passed from within outwards.

If the artery is exposed *above the middle of the arm*,

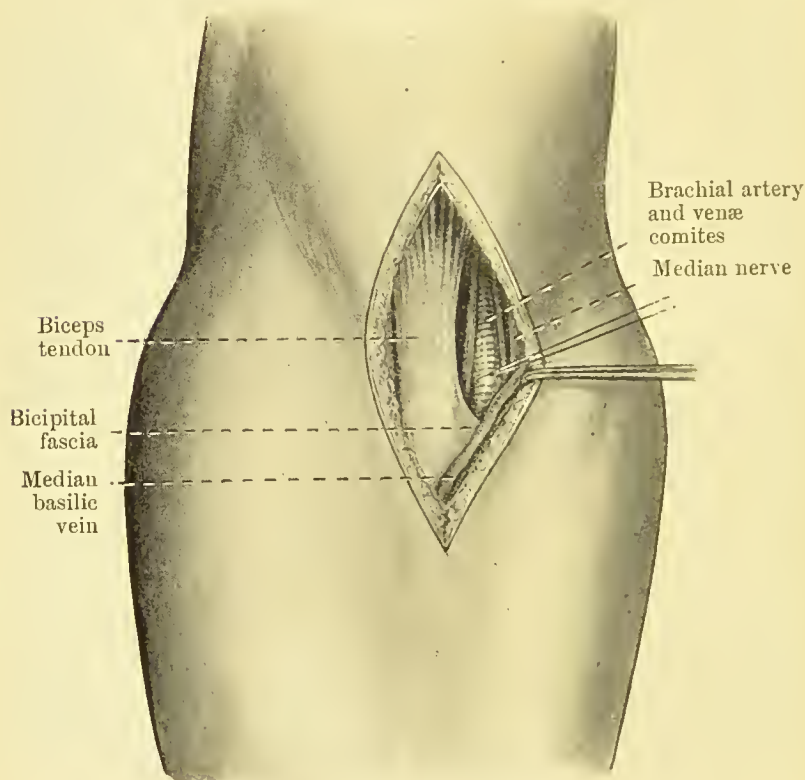


FIG. 22.—Ligation of Right Brachial Artery at the Bend of the Elbow.

the coraco-brachialis comes into view in place of the biceps, and the ulnar nerve lies close to the artery on its inner side.

**Ligation of the Brachial Artery at the Bend of the Elbow** (Fig. 22).—An incision made along the ulnar side of the tendon of the biceps exposes the deep fascia on which lie the median basilic vein and the cutaneous nerve of the



forearm. These having been drawn inwards, the bicipital fascia is defined and divided in the line of the wound. The artery, with its companion veins, lies immediately under the bicipital fascia. The median nerve lies to the ulnar side. The needle is passed from within outwards.

*Collateral Circulation.*—After ligation in the middle of the arm the circulation is maintained by the profunda and superior ulnar collateral branches carrying blood to the vessels which share in the anastomosis around the elbow, namely, the inferior ulnar collateral and the radial, ulnar, and interosseous recurrent branches.

**LIGATION OF THE RADIAL ARTERY.**—The radial artery is the direct continuation of the brachial. Its course is indicated by a line drawn from the middle of the cubital fossa opposite the level of the neck of the radius to the front of the radius where the “pulse” can be felt. In the upper third it is overlapped by the brachio-radialis. In the rest of its course it is superficial. In the middle third the radial nerve lies close to the radial side of the artery. It gives off the following branches: recurrent radial, muscular, superficialis volæ, carpal, and dorsal branches to the thumb and index, and it is continued downwards to form the deep palmar arch.

**Ligation of Radial Artery: In the Upper Third.**—An incision is made in the line of the artery or a little to the ulnar side of it to strike off the intermuscular septum between the brachio-radialis and the flexor carpi radialis, between which muscles it lies. The superficial radial veins and a large branch of the musculo-cutaneous nerve appear upon the fascia. After the deep fascia has been divided the brachio-radialis is pulled to the radial side, and the artery is found lying on the insertion of the pronator teres. It is accompanied by venæ comites, and to the radial side, but some distance off, is the superficial branch of the radial nerve. The needle may be passed in either direction.

**In the Middle Third.**—The incision is made in the line of the vessel, which has the same relations as above. The vessel lies on the radial origins of the flexor longus pollicis and the flexor sublimis digitorum. In this part of its course the superficial branch of the radial nerve

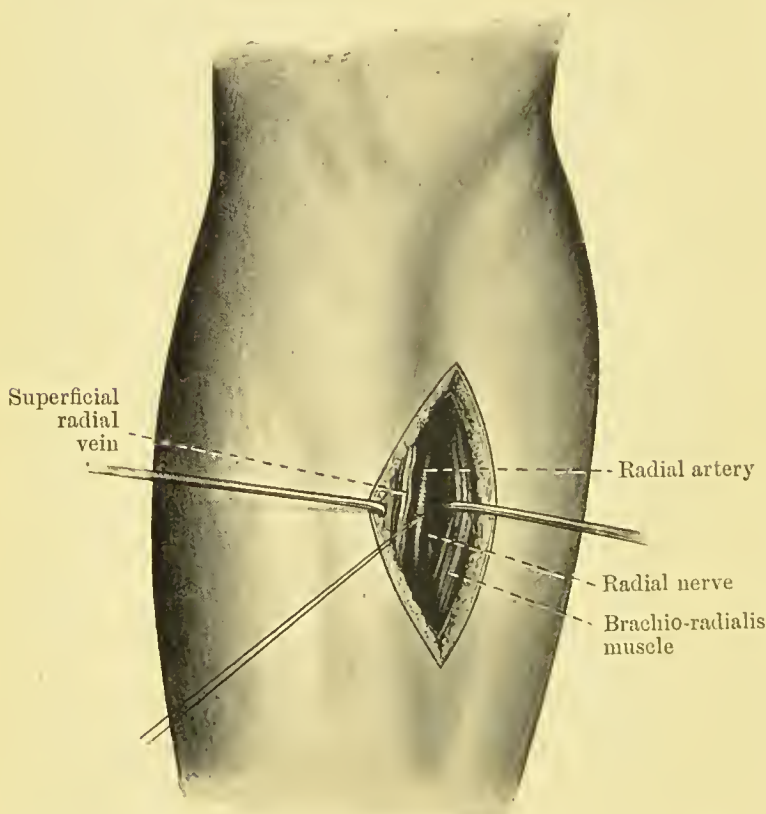


FIG. 23.—Ligation of Left Radial Artery in Upper Third.

lies close to the radial side of the artery under the edge of the brachio-radialis, beneath which it passes towards the back of the forearm.

**In the Lower Third,** just above the wrist. The incision is made in the line of the artery between the tendon of the flexor carpi radialis and the edge of the radius. In the fascia is the commencement of the



superficial radial vein and the terminal branch of the anterior division of the external cutaneous nerve. After the fascia is divided the artery is exposed lying on the bone, accompanied by venæ comites, and with the abductor pollicis longus (extensor ossis) lying to its radial side, and the flexor carpi radialis to its ulnar side. The radial nerve is no longer related to the artery, having passed to the back of the forearm.

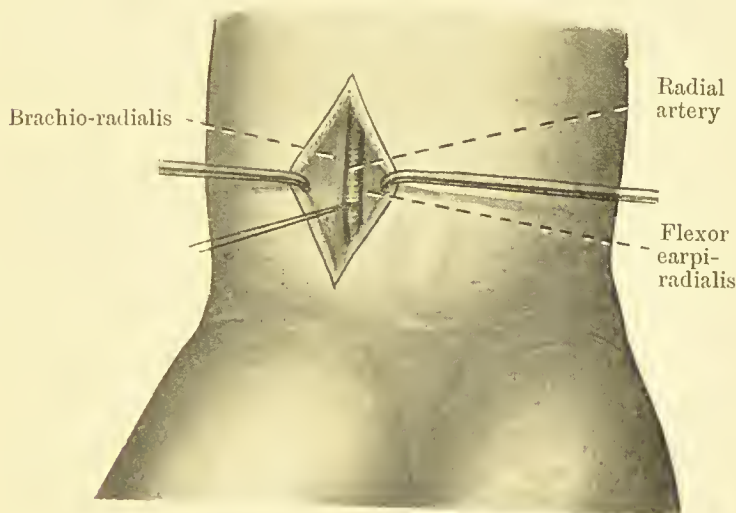


FIG. 24.—Ligation of Right Radial Artery in Lower Third.

**On the Back of the Wrist.**—With the thumb extended and abducted, an incision is made parallel with the abductor pollicis longus (extensor ossis), crossing the artery obliquely. The radial vein and nerve run parallel to the extensors of the phalanges, and are therefore less liable to be injured.

**LIGATION OF THE ULNAR ARTERY.**—The ulnar artery, the larger branch of the two vessels resulting from the bifurcation of the brachial, begins opposite the neck of the radius in the middle of the cubital space, and ends on the radial side of the pisiform bone, where it enters

the palm to form with the superficialis volæ the superficial palmar arch. From the middle of the forearm its course is straight and parallel with the radial artery, the vessel being overlapped by the flexor carpi ulnaris. The upper third of the artery is indicated on the surface by a line curving towards the ulnar side. It lies under cover of the superficial flexor muscles near their origin from the internal condyle. It is accompanied by venæ comites throughout, and in its lower two-thirds the ulnar nerve lies on its ulnar side. The artery rests upon the flexor profundus digitorum. The lower two-thirds of the artery may be indicated on the surface by a line drawn from the internal epicondyle to the radial side of the pisiform bone. It gives off numerous branches in its course, the most important being the common interosseous, which arises in the lower part of the cubital fossa, and passes backwards until at the upper edge of the interosseous membrane it divides into volar (anterior) and dorsal (posterior) interosseous arteries. These arteries pass downwards respectively in front of, and behind, the interosseous membrane.

**Ligation of the Ulnar Artery above the Origin of the Common Interosseous.**—This operation is carried out in the same way as ligation of the brachial at the bend of the elbow.

**In the Middle of the Forearm** (Fig. 25).—An incision is made in the line of the artery or a little to the radial side of this. In the superficial fascia run the anterior ulnar vein and the anterior division of the internal cutaneous nerve of the forearm. After the fascia is divided the space between the flexor carpi ulnaris and the flexor sublimis digitorum is looked for and opened. The finger is then passed deeply to the radial border of the flexor carpi ulnaris, which is drawn to the ulnar side, when the ulnar nerve will be found lying on the ulnar side of the artery.

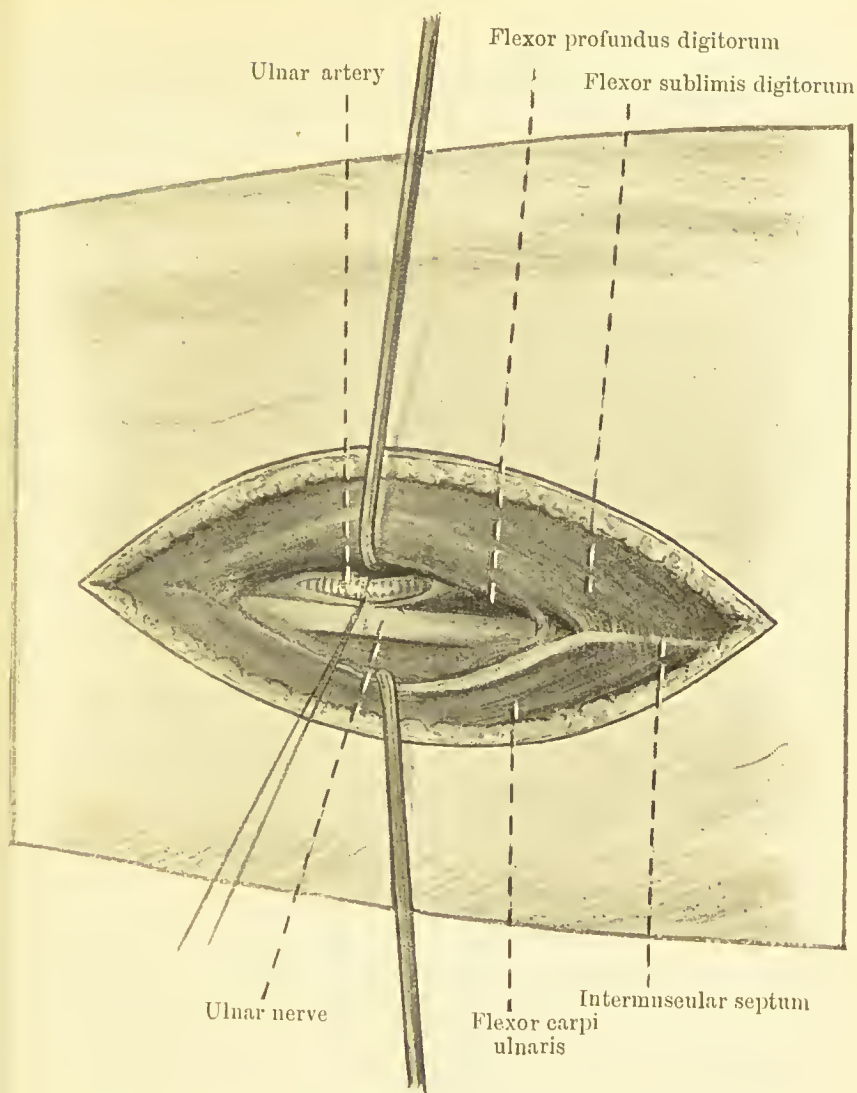


FIG. 25.—Ligation of Left Ulnar Artery in Middle of Forearm.

**In the Lower Third.**—An incision is made in the line of the artery, and the deep fascia having been divided, and the flexor carpi ulnaris drawn to the ulnar side, a special layer of fascia extending from the tendon of the flexor carpi ulnaris to the flexor profundus digitorum is divided and the artery exposed. The ulnar nerve lies to its ulnar side.

## CHAPTER IV

### LIGATION OF THE ARTERIES OF THE ABDOMEN AND LOWER EXTREMITY

ABDOMINAL AORTA. COMMON ILIAC. INTERNAL ILIAC (HYPOGASTRIC). GLUTEAL (SUPERIOR GLUTEAL) AND SCIATIC (INFERIOR GLUTEAL). EXTERNAL ILIAC. FEMORAL: At Base of Scarpa's Triangle; At Apex of Scarpa's Triangle—In Hunter's Canal. POPLITEAL: From Inner Aspect—From Posterior Aspect. ANTERIOR TIBIAL: In Upper Third—In Middle Third—In Lower Third. DORSALIS PEDIS. POSTERIOR TIBIAL.

LIGATION OF THE ABDOMINAL AORTA (Fig. 26).—The abdominal aorta, with the inferior vena cava to its right side, lies behind the peritoneum, in contact with the upper four lumbar vertebræ. At the level of the lower border of the fourth lumbar vertebra, slightly to the left of the middle line, it bifurcates into the right and left common iliac arteries. The point of bifurcation is indicated on the surface of the abdomen a finger's breadth below and to the left of the umbilicus.

The lowest visceral branch is the inferior mesenteric, which comes off about an inch and a half above the bifurcation. The most important branches given off from the lower part are the middle sacral and four pairs of lumbar arteries.

The indications for ligation of this vessel are aneurysm of the common iliac artery extending up to the bifurcation, and aneurysm of the abdominal aorta between the

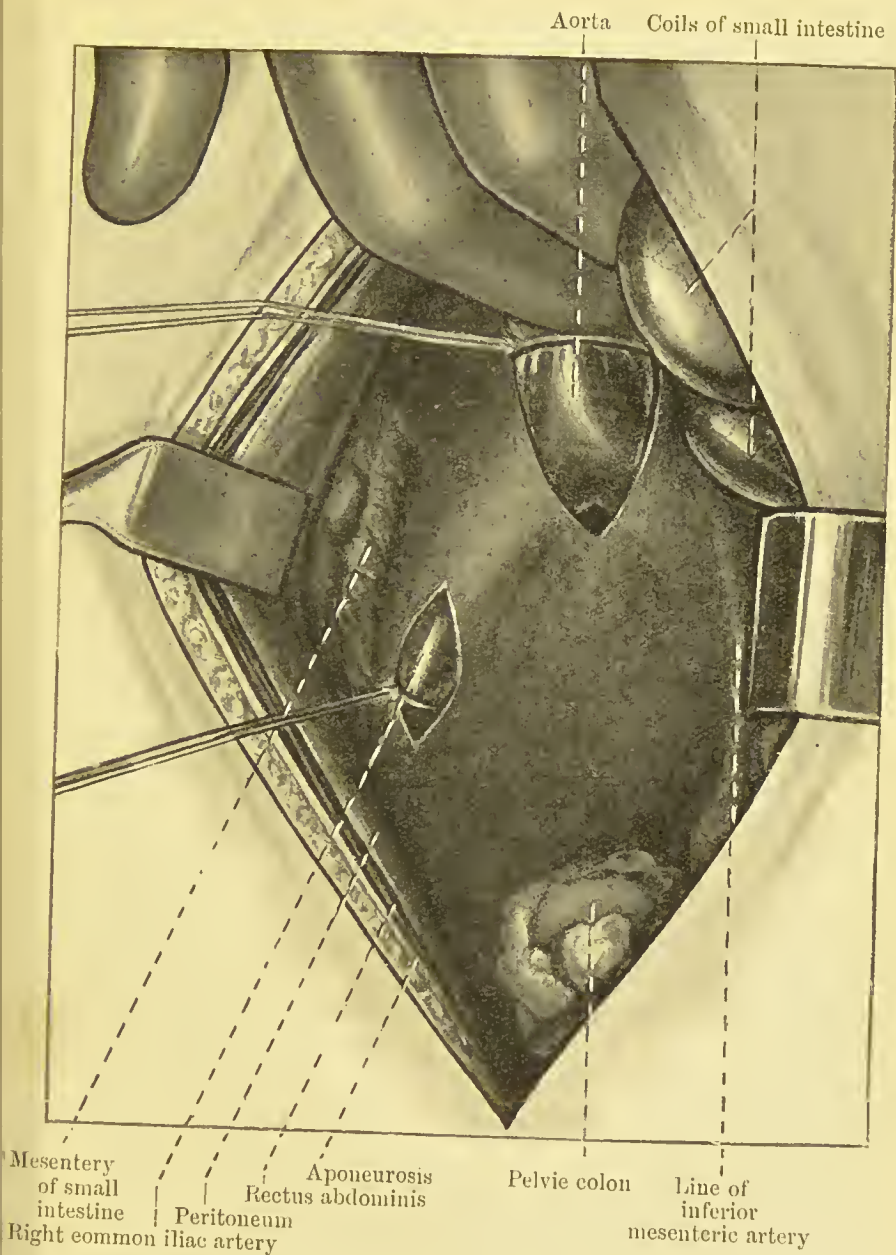


FIG. 26.—Ligation of Abdominal Aorta, and of Right Common Iliac Artery.

origin of the inferior mesenteric artery and the bifurcation. Hitherto no case has been permanently successful in the



human subject, although a patient operated upon by Keen lived for forty-eight days and died of secondary hæmorrhage.

The artery is reached by traversing the peritoneal cavity, and the bowel should be as empty as possible. A vertical incision is made about one inch to the left of the middle line, with its centre opposite the umbilicus. The anterior layer of the sheath of the rectus is divided, the rectus muscle displaced outwards, and the posterior layer of the sheath and the peritoneum divided together. The patient is then placed in the Trendelenburg position, the intestines packed off, and the posterior parietal peritoneum incised towards the left side of the vessel. The sheath is cleared off the artery, care being taken to separate the aortic plexus of the sympathetic, so that it shall not be included in the ligature. Four broad ligatures of kangaroo tendon are carried round the vessel and tied in the form of a double stay-knot so as to occlude the lumen without rupturing any of the coats.

The opening in the peritoneum is then sutured, the abdomen closed in layers, and the patient returned to bed with the limbs elevated and wrapped in cotton wool.

*Collateral Circulation.*—When the ligature is placed below the inferior mesenteric, the collateral circulation is established by an anastomosis between the inferior mesenteric above and the internal pudic (pudendal) below; the lumbar arteries above and the branches of the internal iliac (hypogastric) below; and the internal mammary above and the deep (inferior) epigastric below. Keen's patient survived the operation long enough to show that an efficient collateral circulation can be established.

The extra-peritoneal route has been abandoned.

LIGATION OF THE COMMON ILIAC ARTERY (Fig. 26).  
—The common iliac arteries arise at the bifurcation of the aorta a finger's breadth below and to the left of the umbilicus, at the level of a horizontal line joining the



highest points of the iliac crests. A line drawn with a gentle curve outwards from this point to a point midway between the anterior superior spine and the pubic symphysis indicates the course of the common and external iliac vessels; the upper third of the line corresponding to the common, and the lower two-thirds to the external iliac artery.

Each artery passes downwards and outwards across the bodies of the fourth and fifth lumbar vertebræ on the psoas muscle, and terminates at the level of the lumbosacral articulation in front of the corresponding sacroiliac joint by dividing into the internal (hypogastric) and external iliac arteries. Near the bifurcation the ureter crosses in front of the artery. Behind the right artery the two common iliac veins join to form the inferior vena cava. The left artery is crossed by the inferior mesenteric vessels.

The operation may be performed for aneurysm of the external iliac not suitable for Matas' operation, or as a preliminary to amputations at or near the hip.

The artery is best reached by the trans-peritoneal route. An incision is made in or near the middle line, and, after the abdomen has been opened, the pelvis is raised into the Trendelenburg position to facilitate the displacement of the intestines. There is sometimes difficulty in distinguishing one common iliac from the other, particularly in stout patients. We have found that, by tracing the abdominal aorta to the bifurcation and then noting the effect on the femoral pulse of compressing each iliac in turn, the vessel can be definitely located. The posterior parietal peritoneum is then incised in the line of the artery sufficiently freely to admit of the sheath being cleared. On the right side, the passage of the needle is rendered difficult by the presence of both common iliac veins behind the artery. On the left side, the chief difficulty arises from the inferior

mesenteric vessels crossing the artery. After the vessel has been secured, the opening in the peritoncum is sutured, and the abdominal wound closed.

The operation was formerly attended with considerable mortality, but under aseptic conditions we have found it an eminently satisfactory one.

*Collateral Circulation.*—After ligation of the common iliae an anastomosis is established between (1) the inferior mesenteric above and the hæmorrhoidal branches of the internal iliae below; (2) the uterine, ovarian, and vesical arteries of the two sides; (3) the middle sacral branch of the aorta above and the lateral sacral branches of the internal iliae below; and (4) the internal mammary, lower intercostals, and lumbar arteries above and the deep (inferior) epigastric below.

**LIGATION OF THE INTERNAL ILIAC (HYPOGASTRIC) ARTERY.**—At the bifureation of the common trunk, the internal iliae, about an inch and a half in length, dips down into the pelvis to terminate at the upper border of the greater sciatic notch. The corresponding ureter descends along the anterior aspect of the artery, the vein lies behind the artery, and still farther back is the lumbosacral cord.

It gives off numerous branches to the pelvic viscera and wall, some of which pass to the buttock (gluteal and sciatic), to the thigh (obturator), and to the external organs of generation (internal pudendal).

The principal indication for this operation is a gluteal aneurysm which cannot safely be dealt with by the old operation of opening the sac and securing the open ends of the vessel. Hartmann and Quénu recommended it as a preliminary operation to excision of the rectum by the combined perineo-abdominal route. Annandale performed the operation for gluteal hæmorrhage.

The operation is carried out by the trans-peritoneal

route on lines similar to those for ligation of the external iliac (p. 54).

*Collateral Circulation.*—The collateral circulation is established by an anastomosis between (1) the gluteal and sciatic above with the deep circumflex iliac and branches of the profunda femoris below; (2) the branches of the obturator and pudic arteries of the two sides; (3) middle sacral above and lateral sacral below; and (4) the inferior mesenteric above with the hæmorrhoidal arteries below.

**Ligation of the Gluteal (Superior Gluteal) Artery.**—The gluteal artery, the continuation of the posterior division of the internal iliac (hypogastric), leaves the pelvis through the upper part of the greater sciatic foramen, and after passing through the space between the gluteus medius and the pyriformis, breaks up into its branches under cover of the gluteus maximus. If a line is drawn from the posterior superior iliac spine to the upper border of the great trochanter, the point of emergence of the artery lies opposite the junction of the upper and middle thirds of this line.

To expose the vessel, an incision is made with its centre over the point of emergence. The skin and fascia are divided, and the fibres of the gluteus maximus, which run parallel with the incision, are separated. The fascia over the lower border of the gluteus medius is divided and the muscle drawn upwards. On passing the finger between the gluteus medius and the pyriformis, the artery is felt leaving the greater sciatic foramen. It is accompanied on its upper and lateral aspect by the superior gluteal nerve.

**Ligation of the Sciatic (Inferior Gluteal) Artery.**—The sciatic artery, a branch of the anterior division of the internal iliac, leaves the pelvis through the lower part of the great sciatic foramen, and enters the buttock below the pyriformis. It passes downwards behind and to the inner side of the sciatic nerve

under cover of the gluteus maximus. The incision to expose the artery is made over the middle two-fourths of a line from the posterior inferior iliac spine to the ischial tuberosity. The skin and fascia are divided, the fibres of the gluteus maximus split, the lower border of the pyramiformis defined, and the artery exposed.

LIGATION OF THE EXTERNAL ILIAC ARTERY.—This operation is performed for femoral aneurysm situated too high to admit of ligation of the common femoral itself, or for hæmorrhage in the distribution of the femoral. The course of the artery is indicated by the lower two-thirds of a line curving gently outwards from a point a finger's breadth below and to the left of the umbilicus to a point midway between the anterior superior iliac spine and the symphysis pubis.

The **Trans-peritoneal Operation** is to be preferred in the majority of cases. An incision is made along the lateral border of the sheath of the rectus muscle. The integument having been divided, the anterior layer of the sheath of the rectus is incised and the muscle pulled towards the middle line. The transversalis fascia and the peritoneum are then divided. The patient is placed in the Trendelenburg position and the intestines packed off. On the right side, the posterior parietal peritoneum is incised vertically directly over the artery, which is accompanied on its mesial side by the vein. In passing the ligature from within outwards, care must be taken not to include the ureter, which crosses the artery near its origin. After the artery has been ligated, the opening in the peritoneum is sutured and the abdomen closed.

On the left side, the mesocolon overlies the artery, and the parietal peritoneum has to be split vertically near the middle line and stripped outwards sufficiently to expose the vessel.

When the ligature is to be applied to the lower end



of the vessel an **extra-peritoneal operation** may be done (Fig. 27). An incision is made a finger's breadth above and parallel with the outer part of Poupart's

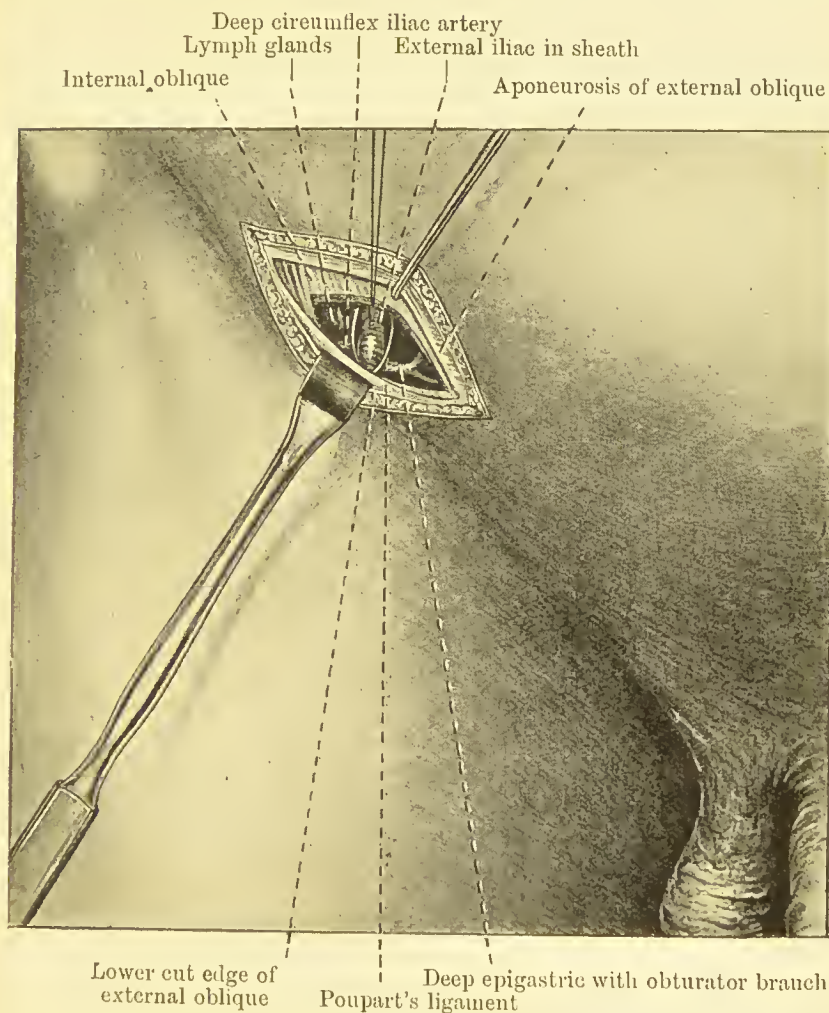


FIG. 27.—Ligation of Left External Iliac Artery ; Extra-peritoneal Operation.

ligament, dividing the skin, the superficial fascia, and the superficial epigastric vessels. The aponeurosis of the external oblique, the internal oblique, and the transversus abdominis muscles having been divided immedi-

ately above Poupart's ligament, and the transversalis fascia a little external to the line of the vessel, the artery is exposed lying among some fatty tissue and lymph glands. The femoral branch of the genito-femoral nerve lies in front of the artery. The vein is to its mesial side, and the fascia covering the psoas to its lateral side. The anterior crural (femoral) nerve lies about three-quarters of an inch farther out, in the groove between the iliacus and the psoas magnus muscles.

*Collateral Circulation.*—A very efficient collateral circulation is established by an anastomosis between the ilio-lumbar branch of the internal iliac above and the deep circumflex iliac below; the gluteal, sciatic, and obturator above and the circumflex and perforating branches of the profunda below; (3) the internal pudic above and the deep external pudic below; and (4) the internal mammary, intercostals, and lumbar arteries above and the deep (inferior) epigastric below.

**LIGATION OF THE FEMORAL ARTERY.**—The femoral artery begins where the external iliac ends, at a point midway between the anterior superior iliac spine and the symphysis pubis, and enters Scarpa's triangle. About an inch and a half from its origin it gives off the profunda branch, and continues onwards as far as the opening in the adductor magnus, through which it passes to become the popliteal. The trunk may be ligated at the base of Scarpa's triangle, and the superficial division either at the apex of the triangle or in Hunter's canal.

With the thigh slightly flexed, abducted, and rotated out, the course of the artery is indicated by the upper two-thirds of a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle.

To expose the **Femoral Artery at the Base of**



**Scarpa's Triangle**, an incision with its centre over the artery is made a finger's breadth below and parallel with Poupart's ligament. The fascia lata is then incised

Lymph glands

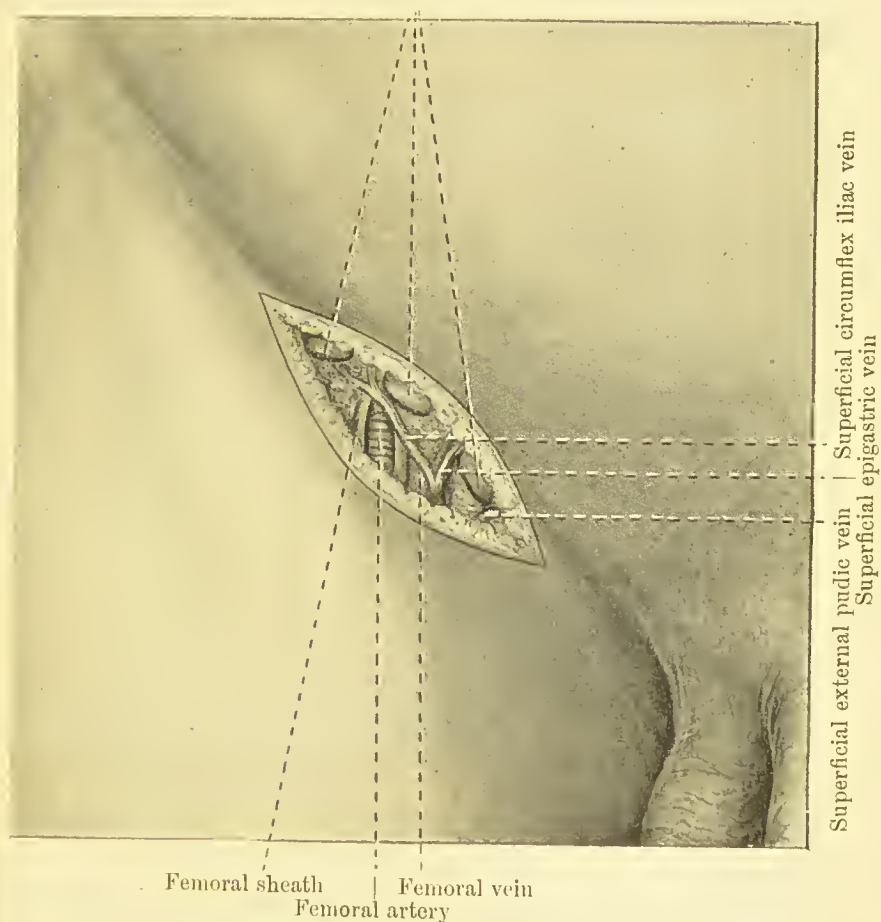


FIG. 28.—Ligation of Right Common Femoral at Base of Scarpa's Triangle.

in the same direction as the skin, and the sheath of the artery exposed. In this part of its course it gives off the superficial epigastric, superficial external pudic, and superficial circumflex iliac, and deep external pudendal branches. The femoral branch of the genito-

femoral nerve lies to the lateral side of the sheath, and the femoral vein lies to the mesial side of the artery in a separate compartment of the sheath. To the lateral aspect and behind lies the ilio-psoas covered by its fascia. The trunk of the anterior crural (femoral) nerve is about half an inch lateral to the artery.

The needle is passed from within outwards, that is from the side on which the vein lies. In the cadaver, care must be taken not to mistake an enlarged lymph gland for the artery.

*Collateral Circulation.*—The collateral circulation is much less satisfactory than after ligation of the external iliac.

To expose the **Femoral Artery at the Apex of Scarpa's Triangle**, an incision is made in the line of the artery, dividing the skin and fascia lata. The internal saphenous vein lies on the fascia to the mesial side of the incision, and the internal cutaneous nerve, often accompanied by a tributary of the saphenous vein, crosses the artery at this level. The mesial edge of the sartorius having been defined, the muscle is pulled outwards and the sheath of the artery exposed. The femoral vein is found passing from the mesial side to lie behind the artery, and the long saphenous nerve is to the outer side. The other branches of the anterior crural (femoral) nerve are under cover of the sartorius.

The needle is passed from within outwards.

*Collateral Circulation.*—As the ligature is placed below the origin of the profunda femoris, the numerous branches of this vessel take part in establishing an efficient collateral circulation. An anastomosis takes place between the external circumflex above and the lower muscular and anastomotic branches of the femoral, the superior articular branches of the popliteal, and the anterior tibial recurrent below; the perforating and terminal branches of the profunda above and the

muscular branches of the femoral, and the museular and superior articular branches of the popliteal below.

To expose the **Femoral Artery in Hunter's Canal**, an

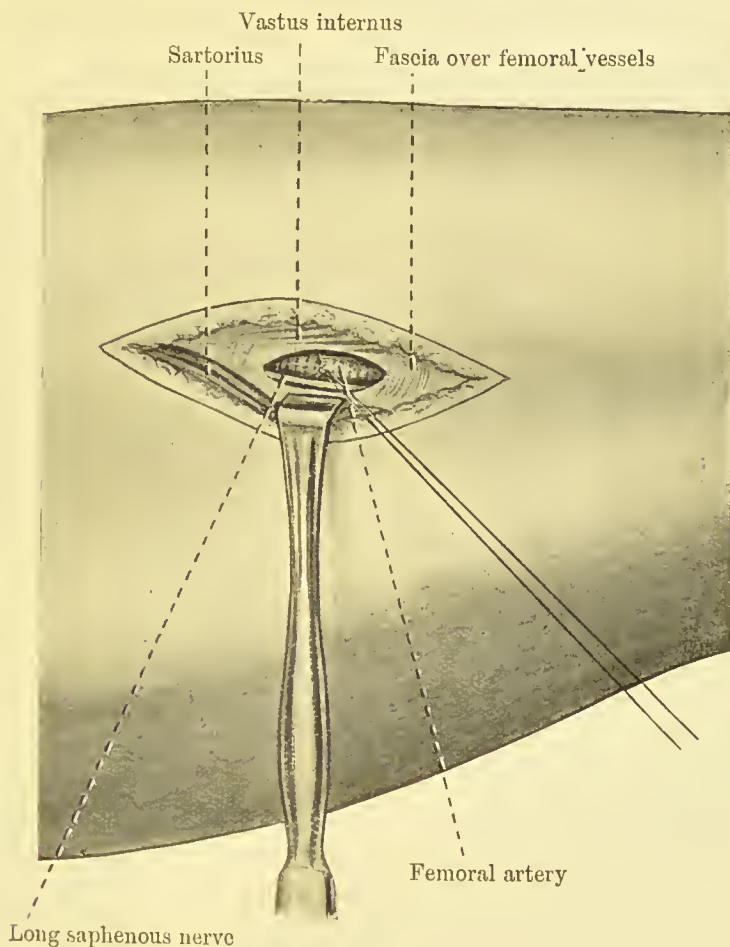


FIG. 29.—Ligation of Left Femoral in Hunter's Canal.

incision is made in the line of the artery (Fig. 29). The large saphenous vein usually comes into view and should be retracted inwards. The outer edge of the sartorius, which is recognised by the longitudinal direction of its fibres, is drawn inwards, and the aponeurosis extending from the vastus internus to the

adductor muscles and forming the roof of the canal is divided in the long axis of the wound. The sheath of the artery then comes into view and is opened, care being taken to avoid the long saphenous nerve, which crosses the artery from without inwards. The vein lies to the outer side of the artery. The needle must be kept in close contact with the artery, and may be passed from whichever side is more convenient.

The *Collateral Circulation* is established in the same way as after ligation at the apex of Scarpa's triangle.

**LIGATION OF THE POPLITEAL ARTERY.**—The popliteal artery extends from the opening in the adductor magnus to the lower border of the popliteus muscle, which is on the same level as the neck of the fibula and the lower part of the tuberosity of the tibia. In its lower half its course is indicated by a line drawn down the middle of the popliteal space. The vessel is deeply placed, lying in contact with the trigone of the femur and the popliteus muscle. It is best tied either at its commencement or near its termination, the middle portion being so deeply placed that access to it is difficult. The upper part is most easily reached from the inner aspect of the thigh, the lower part from the posterior aspect.

**Ligation of First Part of the Popliteal Artery, from the Inner Aspect** (Fig. 30).—With the knee flexed and abducted, an incision is made parallel with and a little behind the round tendon of the adductor magnus, from the junction of the middle with the lower third of the thigh to the adductor tubercle, care being taken to avoid the saphenous vein which lies in the line of the incision. The deep fascia is divided, the anterior border of the sartorius defined and drawn backwards, the round tendon of the adductor magnus cleared, and the dissection carried between it and the sartorius. The artery lies embedded in fat against the femur. The vein lies behind the artery

slightly to its outer side, and the internal popliteal (tibial) nerve posterior to that again.

**Ligation of Lower Part of Popliteal Artery, from the**

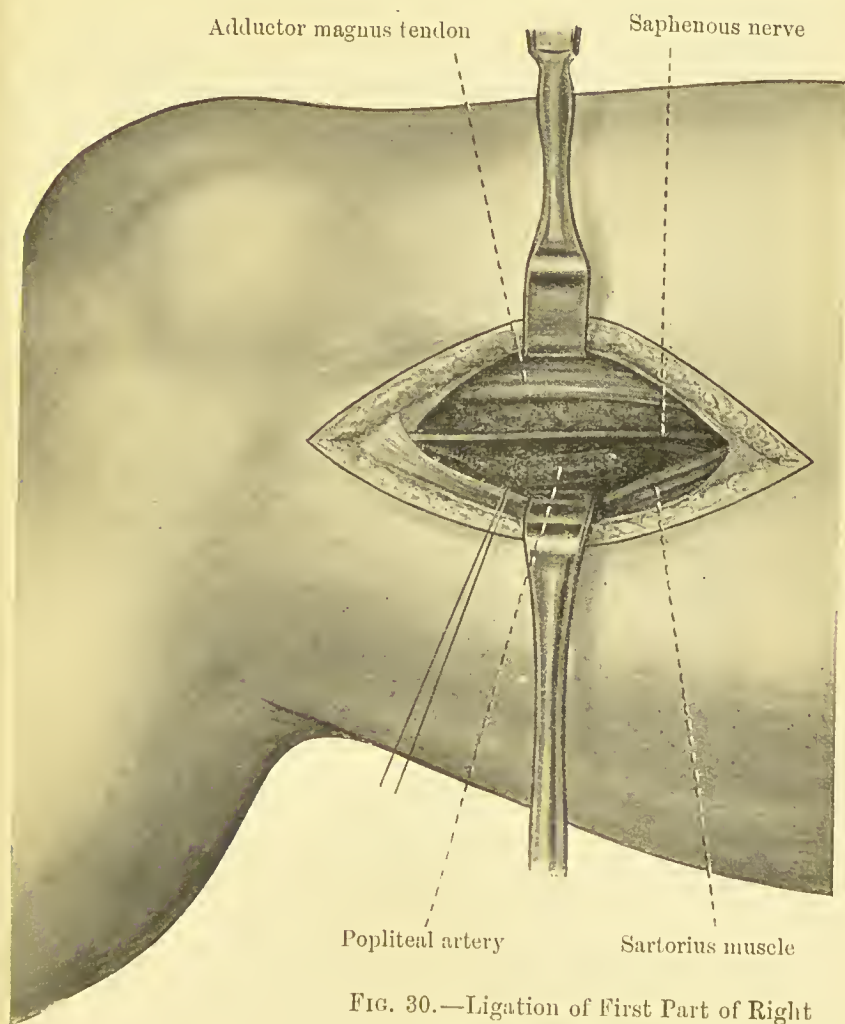


FIG. 30.—Ligation of First Part of Right Popliteal, from inner aspect.

**Posterior Aspect** (Fig. 31).—A vertical incision is made in the middle line of the popliteal space, beginning opposite the level of the knee-joint. The external (small) saphenous vein and the peroneal anastomotie nerve are exposed at the lower part of the wound and hooked aside. After the



deep fascia has been divided and the fatty tissue between the two heads of the gastrocnemius dissected away, the internal popliteal (tibial) nerve is exposed and hooked

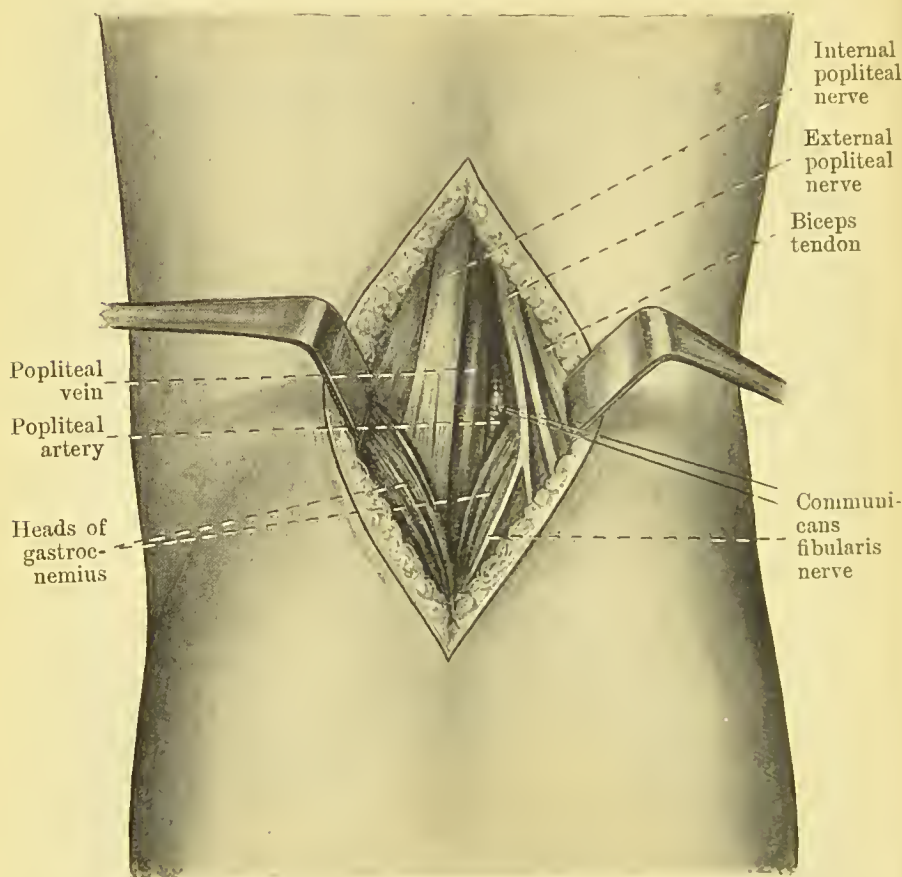


FIG. 31.—Ligation of Lower Part of Right Popliteal, from posterior aspect.

aside. The popliteal vein then comes into view. It is firmly bound down to the subjacent artery by a fibrous sheath, which must be divided before the artery can be exposed lying in the dense fat covering the popliteus muscle.



The needle is passed from the side to which the vein has been retracted.

*Collateral Circulation.*—The vessels entering into the collateral anastomosis, which is a very feeble one, are the external circumflex and anastomotie (arteria genu suprema) branches of the femoral and the superior articular branches of the knee from the popliteal above, with the inferior articular and anterior and posterior tibial recurrent branches below.

**LIGATION OF THE ANTERIOR TIBIAL ARTERY.**—The course of the anterior tibial is indicated by a line drawn from a point midway between the outer tuberosity of the tibia and the head of the fibula, to a point in front of the ankle midway between the two malleoli. The vessel may be exposed in any part of its course by an incision in this line.

**Ligation of the Anterior Tibial Artery in the Upper Third of the Leg** (Fig. 32).—An incision having been made in the line of the artery exposing the deep fascia, search is made for the septum between the tibialis anticus and the flexor digitorum longus. The main difficulty in the operation is to recognise this septum, and as there is no indication of it on the surface of the deep fascia, it can best be found by incising the fascia in the exact line of the artery, and "by passing the finger along the muscles lengthwise, when it is appreciated as the line of least resistance" (Treves). Care must be taken not to enter the interspace between the extensor digitorum longus and the peroneus longus, which is indicated by a white line often marked by a deposit of fat and the emergence of small blood vessels.

After the muscles have been separated and held aside, the outer edge of the tibia is felt for, and the artery, accompanied on its outer side by the anterior tibial (deep peroneal) nerve, is found lying on the interosseous membrane. It is so intimately associated with the venæ

comites and cross branches that these have usually to be included in the ligature, which is passed from without inwards.

**In the Middle Third of the Leg,** the space between the tibialis anticus and the extensor digitorum longus is

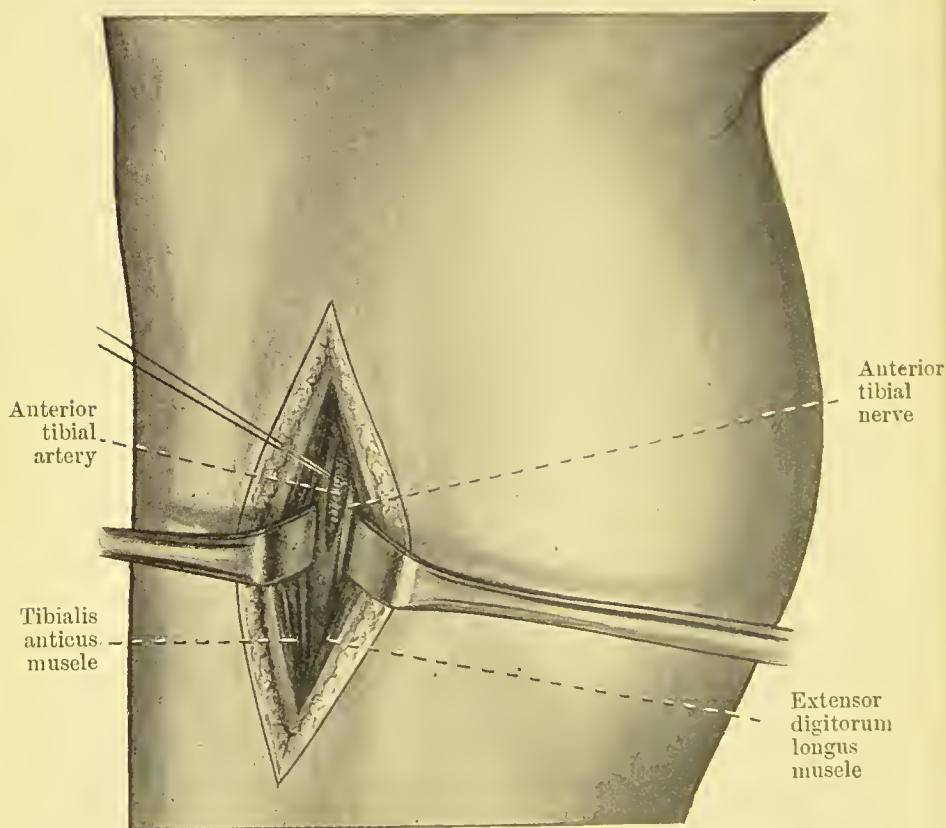


FIG. 32.—Ligation of Left Anterior Tibial in the Upper Third.

opened up, and after these muscles have been separated, the extensor hallucis longus is exposed, with the artery to its inner side. At this level the artery lies under cover of the fibres of the tibialis anticus, and the nerve is on its outer side.

**In the Lower Third** the incision is made between the outer edge of the tendon of the tibialis anticus and the

tendon of the extensor hallucis longus. After the deep fascia has been divided and the extensor hallucis longus

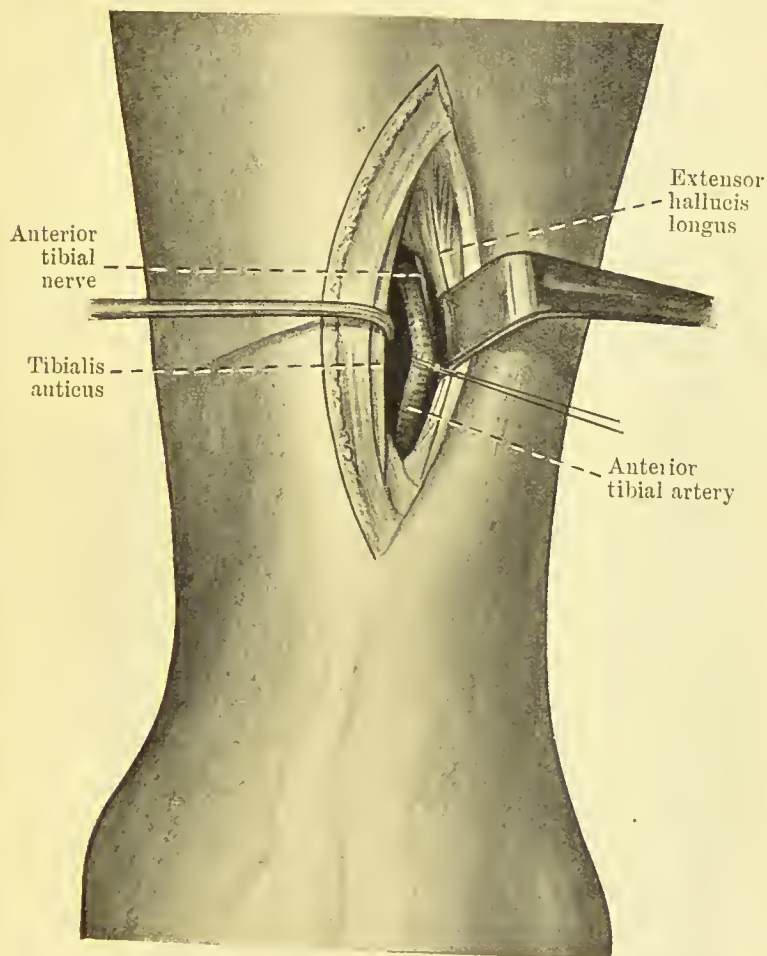


FIG. 33.—Ligation of Left Anterior Tibial in the Lower Third.

retracted outwards, the artery is exposed with the nerve to its outer side (Fig. 33).

LIGATION OF THE DORSALIS PEDIS ARTERY.—The dorsalis pedis—the direct continuation of the anterior tibial—runs in a line from the middle of the front of the ankle to the proximal end of the first interosseous

space, where, after sending on the dorsalis hallucis artery, it passes to the sole of the foot and completes the

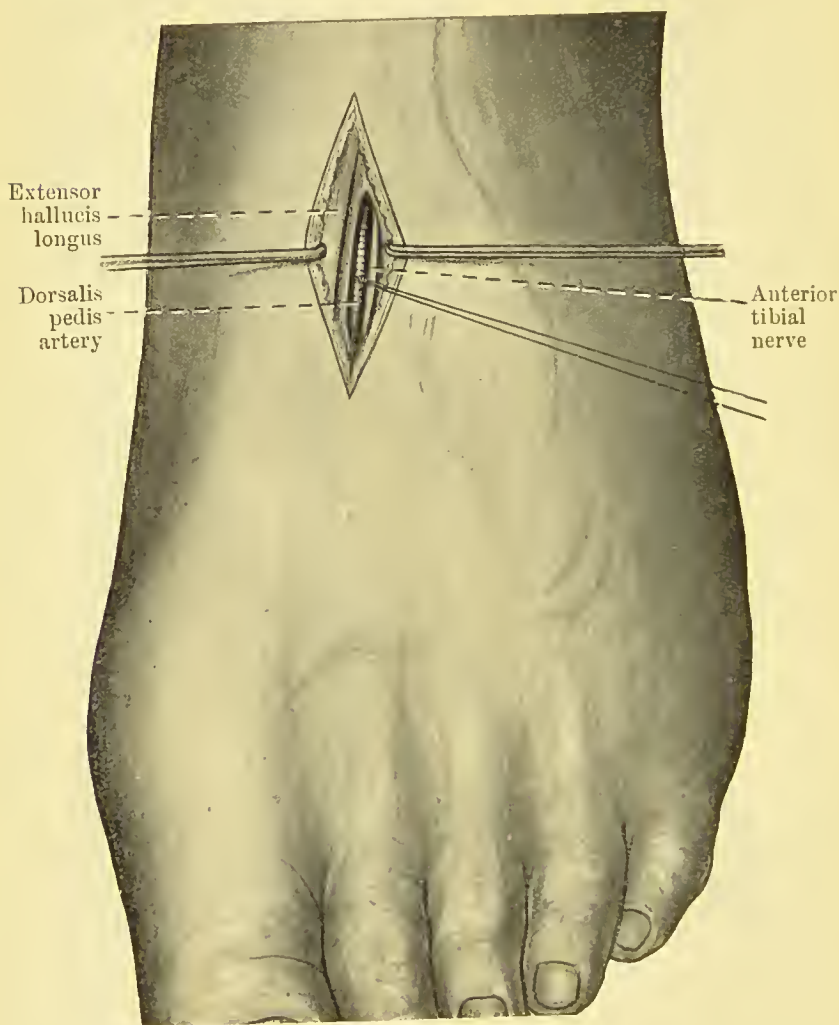


FIG. 34.—Ligation of Left Dorsalis Pedis.

plantar arch. The guide to the artery is the tendon of the extensor hallucis longus, which lies to its inner side. The anterior tibial nerve is on the outer side of the artery (Fig. 34).

**LIGATION OF THE POSTERIOR TIBIAL ARTERY.**—The course of the artery is indicated on the surface by a line drawn from the point at which the popliteal ends in the middle of the back of the ham, to the middle of

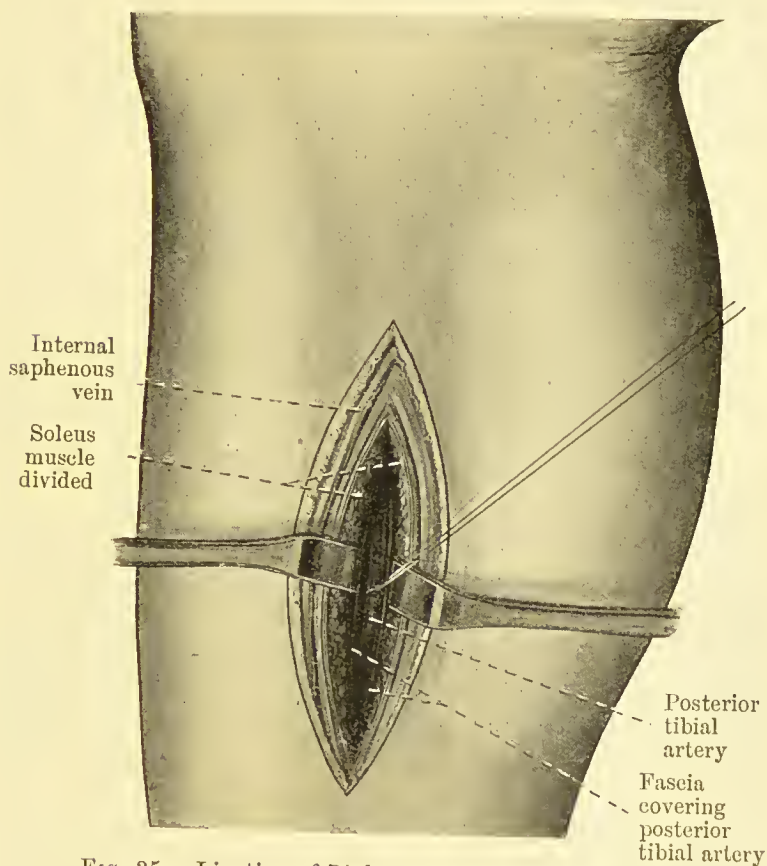


FIG. 35.—Ligation of Right Posterior Tibial in Upper Third of Leg.

the hollow behind the inner malleolus. Near its origin the vessel may be reached by the direct route, but at a lower level, as it lies under the thick muscles of the calf, it is best reached from the inner aspect of the leg.

**Ligation of the Upper Part of Posterior Tibial Artery by the Direct Route.**—To expose the artery above the origin of its peroneal branch, an incision is made in the



middle line of the calf, beginning opposite the level of the head of the fibula. The external (small) saphenous vein and the medial cutaneous nerve of the calf are avoided and hooked outwards. The raphe between the two heads of the gastrocnemius is divided, care being taken to avoid the vessels and nerve entering the two portions of the muscle. On retracting the outer head of the gastrocnemius the tendon of the plantaris and the upper border of the soleus are exposed. The plantaris is hooked aside and the upper fibres of the soleus divided sufficiently to expose the artery lying upon the tibialis posticus muscle, accompanied by *venæ comites*, and with the posterior tibial nerve to its inner side. The needle is passed from without inwards. This route has the advantage that it affords access both to the main trunk of the posterior tibial and to its peroneal branch, and if it is found necessary, the incision can be extended upwards to admit of the popliteal being secured (John Chienc).

**Ligation of the Posterior Tibial Artery in the Upper Third of the Leg by the Indirect Route (Fig. 35).**—An incision is made a finger's breadth behind the inner border of the tibia, care being taken to avoid the internal saphenous vein and the saphenous nerve, which lie in the line of the incision. After the integument and deep fascia are divided, the inner border of the gastrocnemius is exposed and retracted. The oblique fibres of the soleus taking their origin from the tibia, are then brought into view and divided, the edge of the knife being directed towards the tibia. The dense layer of fascia which passes from the posterior surface of the tibia and separates the superficial from the deep layer of calf muscles, is then incised in the long axis of the limb, and the flexor digitorum longus is thus brought into view. The dissection is now carried between this muscle and the fascia covering it, and the artery accompanied by *venæ comites* is reached lying on the tibialis posticus, about an inch and a quarter

beyond the inner border of the tibia, and having the posterior tibial nerve to its outer side. The needle is passed from without inwards to avoid the nerve. This operation is a difficult one and requires a good light. Each structure as it is divided must be well retracted, and in using the retractors in the deeper part of the wound care must be taken not to pull some of the fibres of the flexor digitorum longus over the artery. If this happens,

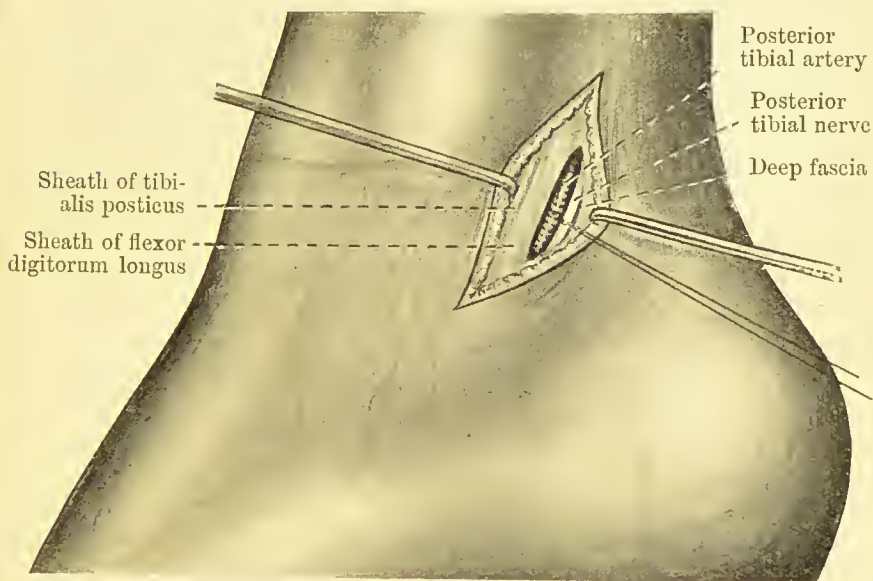


FIG. 36.—Ligation of Right Posterior Tibial behind Inner Ankle.

the dissection will be carried past the artery on to the interosseous membrane.

### Ligation of Posterior Tibial Artery in the Lower Third.

—An incision is made through the skin and deep fascia about a finger's breadth behind the inner edge of the tibia, in the groove between the flexor digitorum longus and the inner border of the soleus, care being taken to avoid the internal saphenous vein and the saphenous nerve. On clearing the inner edge of the soleus and pulling it backwards, the tendon of origin of the flexor

digitorum longus is exposed lying upon the tibia. The thin fascia covering the deep flexors is then divided, and the artery accompanied by venæ comites and with the posterior tibial nerve to its outer side is exposed. The needle is passed from without inwards.

**Ligation of Posterior Tibial Artery behind the Internal Malleolus** (Fig. 36).—An incision is made a finger's breadth behind the posterior border of the internal malleolus. After the strong deep fascia is divided the tendons of the tibialis posticus and flexor digitorum longus can be felt lying behind the internal malleolus. The artery, with its venæ comites, lies to the posterior edge of the flexor digitorum longus, and behind the artery are the posterior tibial nerve and the flexor hallucis longus tendon. The needle is passed from without inwards to avoid the nerve.

## CHAPTER V

### OPERATIONS ON VEINS

VARICOSE VEINS: Trendelenburg's operation—Resection—Mitchell's Operation; Babcock's Operation; Mayo's Operation. VENESECTION AT BEND OF ELBOW. INTRAVENOUS INJECTION OF SALINE SOLUTION. DIRECT TRANSFUSION. LYMPHANGIOPLASTY.

### OPERATIVE TREATMENT OF VARICOSE VEINS OF THE LOWER EXTREMITY

THE superficial veins of the lower extremity are arranged in two systems: the large or internal saphenous, and the small or external saphenous.

The *internal saphenous vein* is formed opposite the base of the first metatarsal by tributaries which drain the dorsum and inner side of the foot. After passing in front of the internal malleolus it runs upwards immediately behind the inner border of the tibia to the knee. It then turns slightly backwards, and runs just behind the internal condyle of the femur, and along the inner aspect of the thigh to the saphenous opening, where it enters the femoral vein. In the thigh it collects all the blood carried in the superficial veins. In the foot and leg it is accompanied by the long saphenous nerve, and in the thigh by branches of the internal cutaneous nerve.

The *external saphenous vein* is formed on the outer aspect of the foot, and passes behind the external malleolus, along the outer border of the tendo Achillis,

thence up the middle of the calf to the lower part of the popliteal space, where it pierces the deep fascia and enters the popliteal vein. In the lower half of the calf it is accompanied by the external saphenous nerve.

In the leg, the saphenous veins communicate freely with one another through their tributaries, and in the lower part of the thigh a branch of considerable size frequently passes between the two systems. Throughout their respective courses both veins communicate also through the deep fascia with the deep inter-muscular veins.

**OPERATIONS.**—The objects aimed at in the operation for varicose veins are: (1) to break the column of blood in the defective veins and so prevent backward pressure on the superficial tributaries; (2) to obliterate or remove the imperfect venous trunks, and so (3) to force the blood to return by the deep inter-muscular veins and the *venæ comites* of the arteries.

Various methods are available to effect these objects, according to the extent of the varix, the disposition of the affected veins, and the condition of the vessel walls. It is to be borne in mind that relapse may occur after even the most extensive and apparently complete operation. The common mistake lies in regarding the visible, tortuous, dilated vein as the trunk of the saphena and removing it only; the trunk of the vein lies deeper, and must be removed to ensure the permanence of the cure.

**Trendelenburg's Operation.**—This operation, which consists in excising a portion of the internal saphenous vein near the saphenous opening, is specially applicable to cases in which the saphenous trunk in the thigh is alone involved in the varix. An incision is made obliquely across the line of the vein, at the level of



the saphenous opening passing downwards and inwards (Fig. 37). The vessel is exposed about an inch below the opening, and after being cleared a segment, two or three inches in length, is excised between ligatures.

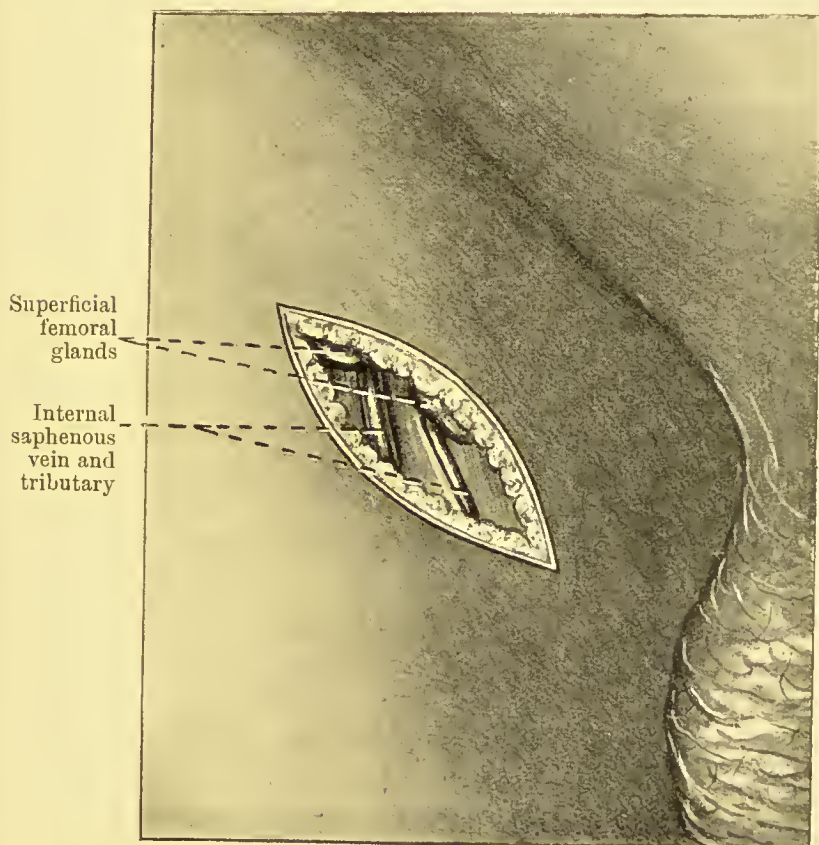


FIG. 37.—Incision to Expose Internal Saphenous Vein close to Saphenous Opening.

If, as is frequently the case, the vessel is double in the upper part of its course, a portion of each trunk must be resected.

**Resection of Varices.**—When the varix is widespread, and especially if more than one trunk is implicated, it is better to remove several portions of the vein, each about two or three inches long, at intervals along

its course. This method is to be selected also when the vessels are highly tortuous and arranged in clumps, and when the vessel walls are unduly hard.

It is well to define the portions to be removed before commencing the operation. This is best done by applying a constricting rubber band to the upper part of the thigh sufficiently tightly to render the superficial veins prominent, and, after the skin has been purified, making a fine scratch with a needle-point along the course of the selected segments. The constricting band is then removed, and the limb elevated for a few seconds to empty the veins. To keep the veins empty, the limb may be suspended by the foot to an ordinary leg-rest.

In the upper third of the thigh, as the internal saphena is sometimes double, it is best to make oblique incisions passing downwards and inwards across its course; in the lower part of the thigh and in the leg, the incisions may be made in the line of the vessel.

The veins are cleared by blunt dissection, care being taken to isolate them from the accompanying cutaneous nerves, and ligated above and below. The intervening portion is then removed, any tributaries entering it being seized with forceps and subsequently tied. The wounds are closed with horse-hair sutures without drainage.

In cases in which there is no thrombosis and the walls of the veins are not unduly thickened, we have obtained satisfactory results by the method suggested by A. B. Mitchell. Through a transverse incision made just below the saphenous opening the internal saphenous vein is exposed, clamped between two pairs of forceps and divided. The upper end is ligated, and by pulling on the forceps attached to the distal end the line of the vessel beneath the skin is easily located. A second incision is made some distance below

the first, and the vein is again picked up, clamped, and cut across. By pulling alternately on the upper and lower forceps the intervening segment of vein can be avulsed, and the tributaries being torn do not bleed. The process is repeated at intervals along the course of the affected veins, until the whole length of the vessel has been removed. The small skin incisions are then closed with sutures.

**Complete resection** of the whole length of the varicose vein and its tributaries, as recommended by Madelung, Terrier, and others, we consider a needlessly severe and tedious procedure, which holds out no better prospect of permanent cure than simpler methods.

**Sapheno-femoral Anastomosis.**—Delbet's proposal to establish an end-to-side anastomosis between the internal saphenous and femoral veins about four inches below the junction of these vessels, is based on the existence of functional valves in the upper part of the femoral vein. The vessels having been exposed in Scarpa's triangle, a considerable length of the saphenous vein is loosened from its surroundings to ensure that there will be no tension on it after the anastomosis is made. The tributaries and accessory saphenous veins having been ligated, the main trunk is doubly clamped, its upper end ligated, and the vessel cut across obliquely. The femoral vein is then isolated, doubly clamped, and an opening made between the clamps into which the lower end of the saphenous is implanted by a procedure similar to that employed in end-to-side anastomosis of intestine. The upper clamp securing the femoral vein is first removed, then the lower, and finally that on the saphenous. The sartorius and adductor muscles are drawn over the junction and sutured together. The patient is kept in bed for from six to eight weeks.

**Babcock's Operation.**—An oblique incision is made exposing the internal saphenous in the upper part

of the thigh, the proximal end of the vessel is tied, and the vein cut across. Into the distal end a steel stylet about 26 inches long with an acorn point at each end (Fig. 38) is passed, and pushed along the lumen of the vein as far as it will go. A second incision is made over the bulb where it is arrested, and a double ligature is passed round the vein, one securing the proximal end to the bulb, the other occluding the distal end. The vessel is cut across, and traction is now made on the stylet from above, so that the vein is torn out of its bed and from its tributaries and comes away attached to the instrument. If there is any obstruction to the passage of the stylet from above, the vein may be exposed lower

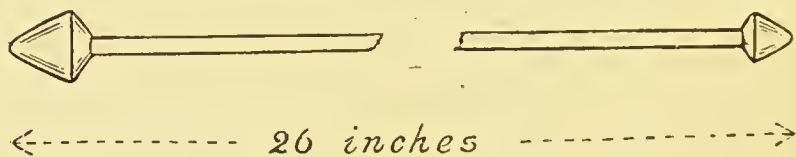


FIG. 38.—Babcock's Stylet.

in the limb and the instrument passed from below upwards. In cases in which the vessel walls are not rendered brittle by calcareous deposits, and in which there is not excessive tortuosity or sacculation, we have found this procedure very satisfactory.

**Mayo's Operation.**—C. H. Mayo employs instruments known as the “vein-stripper forceps,” and the “ring-enueleator” which consists of a quarter-inch steel ring with a long stem, like a blunt uterine ring-curette bent to an angle near its tip.

The saphenous vein is exposed and divided in the upper third of the thigh, and the proximal end ligated. The stripping forceps are first pushed along the vein for some distance, and then through the ring of the enueleator the distal end of the vein is threaded, and by a gentle pushing movement the ring is forced down the



vessel as far as it will go, tearing off the lateral branches in its progress. A small incision is now made over the ring, and through this the isolated segment of vein is withdrawn. This manœuvre is repeated until a sufficient extent of the vein has been removed. The method is not suitable when the veins are brittle, when there are pouches or calcareous deposits in their walls, or when there has been phlebitis and periphlebitis binding the coils together.

**VENESECTION OR PHLEBOTOMY AT THE BEND OF THE ELBOW.**—The superficial veins at the bend of the elbow are those most frequently selected for the withdrawal of blood by venesection. A bandage is applied round the upper arm sufficiently tightly to compress the superficial veins without constricting the arteries. The vein selected, preferably the median basilic, is steadied by pressing on it with the thumb immediately below the point at which it is to be opened. With a narrow-bladed knife the overlying skin and the vein are trans-fixed laterally, and a valvular opening made by cutting outwards, care being taken that the opening in the vessel is exactly opposite that in the skin, and that the skin incision is larger than that in the vein. The thumb having been removed, the blood is allowed to flow into a measuring-glass. The flow may be increased if the patient is able to perform grasping movements, so as to drive the blood from the deeper into the superficial veins. When the desired quantity (8 to 20 ounces) has been withdrawn the constricting bandage is removed, and a pad of gauze applied over the puncture and fixed in position with a figure-of-eight bandage. This pad may be removed in two or three days, but the patient should carry his arm in a sling for about a week.

**INTRAVENOUS INFUSION OF SALINE SOLUTION.**—The fluid introduced is normal physiological salt solution—



80 grains, roughly a teaspoonful, of sodium chloride dissolved in a pint of boiled distilled water at a temperature of about 100° F. In cases in which the blood pressure is markedly lowered—for example, in post-operative shock—7 or 8 minims of adrenalin (1 in 1000) may be added to the solution.

The apparatus consists of a small glass or metal nozzle to which is fixed a rubber tube from 4 to 6 feet in length about the size of a No. 10 catheter, with a glass funnel attached. It is an advantage to have a glass connection in the tubing, so that air bubbles may be seen and the flow stopped before the air reaches the nozzle. The apparatus is filled with the solution before the nozzle is introduced.

The median basilic vein is made to stand out by applying a constricting band round the upper arm, and about an inch of the vessel having been exposed through an incision made in its long axis, two catgut ligatures are passed round it with an aneurysm needle, and the lower ligature tied so as to occlude the vessel. A V-shaped flap, with its apex downwards, is cut in the anterior wall of the vessel by means of scissors curved on the flat, or by transfixing the wall with a short narrow-bladed knife, and the nozzle introduced and retained in position by tightening up the higher ligature with a double or treble first loop of a surgeon's knot. The solution is allowed to flow slowly into the vein, care being taken that no air enters. The rate of flow is regulated by raising and lowering the funnel. As a working rule, it may be said that it should take about fifteen minutes to introduce a pint of solution. When the desired quantity—from 1 to 3 pints—has been introduced the nozzle is withdrawn, the ligature being at the same moment tightened and secured. The skin is then sutured and a dressing applied.

**Direct Transfusion of Blood.**—Direct transfusion from

an artery of the donor to a vein of the recipient may be performed by means of a curved glass tube several inches in length, and furnished at each end with a flange to prevent slipping when in position. The tube is prepared by dipping it into melted paraffin, the excess of which is got rid of by shaking.

The donor's radial artery at the wrist is isolated for a distance of about an inch, its distal end being ligated and its proximal end secured in a light clamp. The median basilic vein of the recipient is next exposed and ligated at its distal end. The donor's artery is then cut across and one end of the glass tube inserted and secured in position with a ligature. A valve-like opening is next made in the vein of the recipient, and the other end of the glass tube inserted into it and the blood allowed to flow for from twenty to thirty minutes.

LYMPHANGIOPLASTY.—Sampson Handley, in 1908, devised a means of diminishing the lymphatic œdema which frequently results from blocking of the lymphatics of the arm in cases of recurrent cancer of the breast, by burying in the subcutaneous tissues a number of strands of silk, which form a system of capillary drains for the lymph. The plan has been adapted also to the persistent œdema which sometimes follows thrombosis of veins, and to various forms of elephantiasis.

The procedure is carried out as follows: A small incision is made into the subcutaneous tissue near the distal extremity of the affected limb, and a long probe is pushed point first up the limb till only the eye projects from the wound. The point of the probe is then cut down upon, and the silk thread, which is as long as the entire limb, is threaded into the eye and pulled into the track of the probe. The probe is then reintroduced into the upper wound and pushed farther up, and this is

repeated until the silk is carried to the upper limit of the indurated area. The ends of the silk strands are carried well beyond the oedematous area into healthy tissue, and the various incisions are closed with horse-hair sutures.

## CHAPTER VI

### OPERATIONS ON NERVES

GENERAL : Nerve Suture—*Primary* ; *Secondary*—Nerve Bridging—  
Nerve Implantation—Avulsion of Nerves. Neurexeresis

#### NERVE SUTURE

**Primary Suture.**—The operation for reunion of a recently divided nerve is spoken of as “primary suture,” and is called for in all cases in which a nerve trunk has been accidentally cut across, either in the course of an operation or otherwise. Division of a nerve by a bullet, or laceration by a fractured bone, may also necessitate primary suture.

For the success of the procedure it is essential that the wound be aseptic, that complete hæmostasis be secured, that the ends of the nerve be approximated without tension, and that the nerve be handled as gently as possible.

As the suturing of the ends of the nerve is extremely painful, an anæsthetic is required. The wound must be enlarged in the long axis of the affected nerve, as the ends—especially the proximal end—are usually retracted. The ends having been identified are brought into contact, and secured to each other by the finest chromicised catgut carried in a round needle, such as is used for the intestine. If the ends of the nerve are bruised or torn, fresh surfaces should be obtained by cutting them across with a sharp bistoury rather than with scissors, which tend to crush the nerve elements.

One or more *approximation sutures* are first passed through the two segments of the nerve about half an inch beyond the cut ends, and these are drawn just tight enough to obtain accurate apposition. To prevent lateral displacement of the ends, a series of *coaptation* stitches is passed through the sheath close to its cut edges (Fig. 39*b*). To prevent the ingrowth of fibrous tissue and adhesion to surrounding structures, the sutured nerve should be enclosed in chromicised Cargile membrane, a decalcified bone tube, or the sterilised artery of a dog or calf. The artery is prepared by being stretched on a glass rod, fixed in formalin, and then boiled.

A small glass or rubber drainage tube should be inserted and left in for the first twenty-four or forty-eight hours. Precautions must be taken that no traction shall be put upon the sutures during the process of repair, and this is best ensured by fixing the limb in the flexed position by means of a splint or plaster of Paris.

If a nerve is only partly cut across, a catgut suture should be inserted to bring the nerve fibres together and to close the sheath and prevent the ingrowth of fibrous tissue.

**Secondary Suture.**—When the attempt to reunite a divided nerve is delayed until after the original wound has healed and degeneration has taken place in the peripheral end, the operation is spoken of as “secondary suture.”

The procedure is more difficult than primary suture, as the ends of the nerve have usually retracted from one another to a variable extent, and are often involved in the scar tissue. Further, if any considerable time has elapsed since the injury, changes will have taken place in the nerve, the proximal end becoming bulbous from overgrowth of branching axis cylinders and young fibrous tissue, while the distal end is degenerated and repre-



sented by a fibrous cord (Fig. 39). The identification of the ends of the nerve is facilitated by employing a tourniquet, but this should be removed as soon as the ends have been isolated, to minimise the pressure effects on the nerve trunk and to diminish the oozing which follows the prolonged use of a constricting bandage.

The proximal end is best secured by exposing the nerve a short distance above the scar, and tracing it down till the bulb is reached. This is freed from the scar tissue in which it is buried. The distal end is then sought for and similarly freed. If there is difficulty in finding it among the scar tissue, a fresh incision may be made a little lower down and the nerve traced upwards. By gently stretching the nerve, accurate apposition of the ends without tension can usually be secured.

The two segments of the nerve having been isolated, a portion of the bulbous enlargement on the proximal end and the fibrous upper extremity of the distal end, are cut off with a sharp knife, and the fresh surfaces are brought into apposition and sutured in the same way as in primary suture (Fig. 39). To relax the nerve, the limb must be fully flexed and fixed in a splint until union has taken place.

If the gap left after resecting the ends is too wide to admit of approximation, recourse must be had to "nerve bridging" or to "nerve implantation."

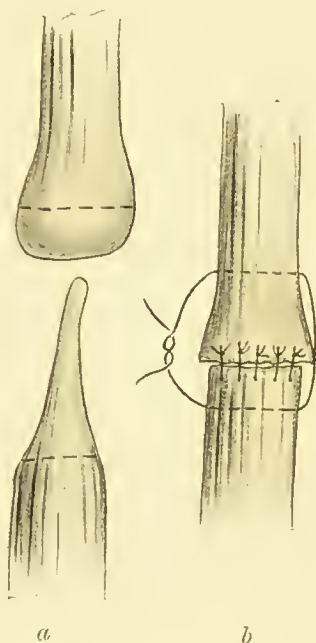


FIG. 39.—Secondary Nerve Suture.

*a.* Line of section of ends;  
*b.* Relaxation and coaptation sutures introduced.

**Nerve Bridging.**—Various methods of bridging over the gap between the ends of the nerve are employed.

If the gap does not exceed an inch and a half or two inches, strands of chromic catgut are passed between the two ends so as to form a scaffolding along which the reparative material may grow (Fig. 41). The union is strengthened and the growth of the reparative

material is directed along the catgut fibres, by encircling the united portion with a sheath of fascia or a piece of a dog's artery hardened in formalin—*tubular suture* (Fig. 42). According to Sherren, the best encircling material to employ is a portion of one of the patient's superficial veins resected for the purpose.

A portion of the sciatic nerve of a dog or other animal, or a portion of nerve from a recently amputated limb may be grafted into the gap (*nerve transplantation*) (Fig. 43). In this method all tension can be obviated,

as the graft may be made of sufficient length to fill the gap. Great care is necessary, however, to ensure that the graft is obtained and transferred under absolutely aseptic conditions. The ideal method of performing nerve transplantation is to resect a segment of one of the patient's sensory nerves and implant it in the gap—for example, a portion of the radial nerve may be resected and used to fill a gap in the musculospiral (Dean).

If two adjacent nerves have been damaged at the

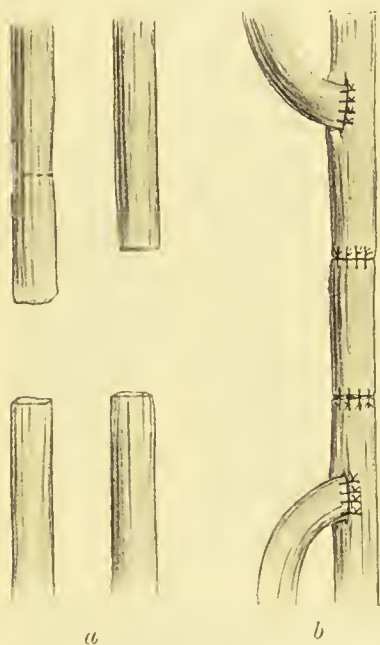


FIG. 40.—Method of Nerve Bridging and Transplantation. (See Text.)

same time, and both are rendered functionless on account of the wide gap between the ends, a portion of one may be resected and grafted into the other, and when the function of the repaired nerve has been restored the

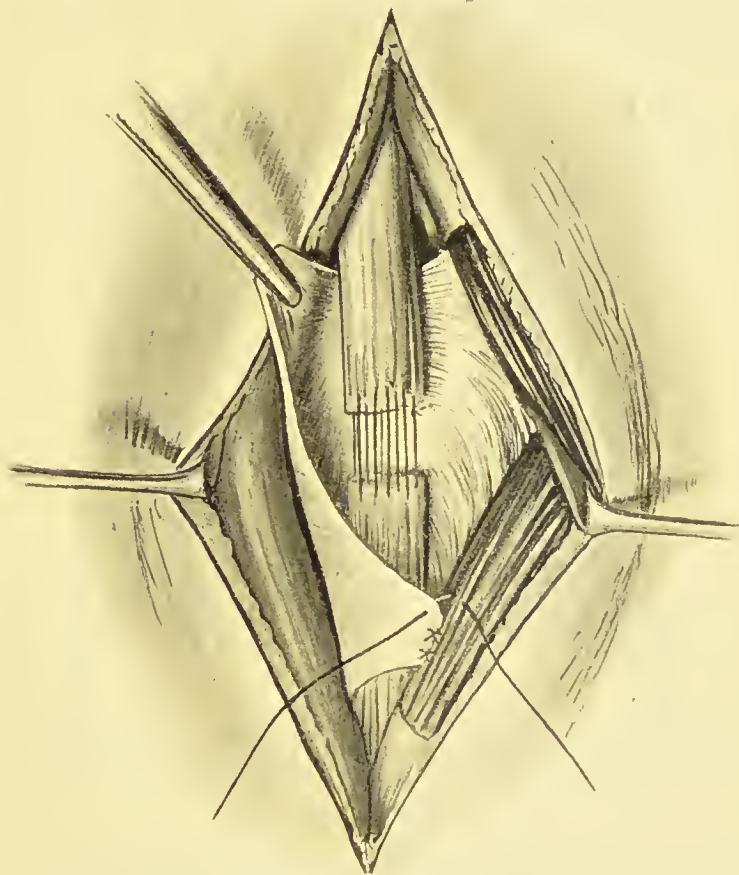


FIG. 41.—Nerve Bridging.

Strands of catgut introduced to bridge the gap; fascia being folded over the union.

paralysed one may be implanted into it at a higher level (Fig. 40).

**Nerve Implantation.**—This procedure consists in attaching one nerve to another in such a way that impulses will pass between them.

The paralysed nerve is exposed and freed sufficiently to enable it to be approximated to the healthy one without tension. A vertical incision is then made through the sheath of the intact nerve, exposing some of its axis cylinders, and after being rawed the distal end of the paralysed one is inserted into the slit and



FIG. 42.—Nerve Bridging.  
Portion of dog's artery encircling  
the united ends.



FIG. 43.—Nerve Bridging.  
Portion of nerve from amputated  
limb grafted into paralysed  
nerve.

fixed there by catgut sutures passing through the sheaths of both (*nerve anastomosis*) (Fig. 44).

When the gap cannot be efficiently "bridged," both ends of the damaged nerve may be implanted in the nearest intact trunk—for example, the separated ends of the median may be attached to the ulnar (Fig. 45).

In addition to being employed in cases of nerve injury with loss of tissue, for example in the resection of a tumour, nerve implantation is used to restore function

by connecting a paralysed nerve with an adjacent active one, for example, implanting the distal end of the paralysed facial nerve into the intact hypoglossal (p. 99). In cases of paralysis following anterior poliomyelitis also, the nerve supplying the paralysed group of muscles may be implanted into the trunk supplying the active muscles,—for example, the paralysed



FIG. 44.—Nerve Implantation.  
Distal end of paralysed nerve im-  
planted in side of intact nerve.



FIG. 45.—Nerve Implantation.  
Both ends of paralysed nerve im-  
planted in side of intact nerve.

anterior tibial may be implanted into the healthy posterior tibial, or the paralysed external popliteal into the healthy internal popliteal (*nerve crossing*).

**Avulsion of Nerves—Neurexeresis.**—This procedure is frequently employed in cases of intractable neuralgia, particularly of the branches of the trigeminal nerve. In performing avulsion after the method of Thierseh, a short portion of the nerve is exposed, seized with artery forceps, and slowly twisted, one half turn of the forceps



being made every thirty seconds. C. H. Mayo recommends that the nerve be twisted one way until it is tight, and then unrolled and twisted in the opposite direction, and this is repeated until the portion comes away in the grasp of the forceps. The advantages of avulsion over resection are that a considerably longer segment of the nerve can be removed, and degeneration takes place not only up to the ganglion cells, but extends even into bulbo-spinal root (Gehuechten).

## CHAPTER VII

### OPERATIONS ON THE CRANIAL NERVES

TRIGEMINAL : OPHTHALMIC DIVISION : *Supra-orbital ; Supra-trochlear ; Frontal ; Nasal.* MAXILLARY DIVISION : *Avulsion in floor of orbit ; Extra-cranial division at base of skull.* MANDIBULAR DIVISION : *Inferior dental and lingual ; Mental ; Lingual from mouth ; Auriculo-temporal ; Buccal ; Extra-cranial division at base of skull.* NERVE ANASTOMOSIS : FACIAL AND HYPOGLOSSAL. FACIAL AND SPINAL-ACCESSORY.

OPERATIONS ON THE TRIGEMINAL NERVE.—The most common indication for operating on the branches of the trigeminal nerve is severe neuralgia. Stretching of the nerves alone is of no use; a segment of the nerve must be resected or avulsed, and the bony canal through which it passes blocked with a silver screw (C. H. Mayo). From such operations, however, the relief is, as a rule, only temporary.

The operation of *Removal of the Gasserian Ganglion* is described with Operations on the Skull.

OPHTHALMIC DIVISION.—**Supra-orbital Nerve.**—This nerve, the largest terminal branch of the ophthalmic division of the trigeminal, emerges from the orbit in the supra-orbital notch at the junction of the middle with the inner third of the upper margin of the orbit, and passes vertically upwards to supply the frontal portion of the scalp. The nerve lies directly upon the periosteum, underneath the fibres of the orbicularis palpebrarum

muscle, with the supra-orbital vessels to its outer side and on a more superficial plane. An incision is made along the supra-orbital margin with its centre opposite the notch, and after the fibres of the orbicularis have been separated the nerve is found as it leaves the notch. The artery may be pulled to the outer side or clamped and divided. The nerve is raised by passing an aneurysm needle under it, and divided well up on the scalp; the proximal end is then seized with artery forceps and as much of the nerve avulsed as possible. The advantages of the incision in the line of the eyebrow are that it leaves an inconspicuous scar and avoids the branches of the facial nerve supplying the orbicularis, which enter from the outer side.

The **Supra-trochlear Nerve**, which passes upwards from the inner angle of the orbit, is exposed by a similar operation, the incision being made over the inner half of the eyebrow.

When both the supra-orbital and supra-trochlear nerves are involved, they should be traced back under the periosteum of the roof of the orbit to the **Frontal Nerve**, which is then avulsed.

The **Nasal** branch, which supplies the inner surface and tip of the nose, is exposed by an incision carried along the inner third of the lower border of the eyebrow and curving downwards towards the bridge of the nose. The periosteum is raised from the roof and inner wall of the orbit till the nerve is seen entering the anterior ethmoidal foramen. It is then seized with forceps and avulsed.

**MAXILLARY DIVISION.**—The portion of the second division of the nerve selected for operation extends from the foramen rotundum across the spheno-maxillary (pterygo-palatine) fossa to the infra-orbital canal, from which it emerges on the face by the infra-orbital foramen, at a point from a quarter to half an inch

below the junction of the inner and middle thirds of the lower orbital margin.

**Avulsion of the Maxillary Nerve in the Floor of the Orbit.**—An oblique incision, the centre of which lies over the foramen, is made in the natural fold of the face, and exposes the fibres of the orbicularis palpebrarum and of the levator labii superioris muscles. These having been separated, an incision is made down to the bone immediately below the orbital margin, and the periosteum is stripped downwards until the nerve is reached as it emerges from the foramen. After the infra-orbital artery has been isolated, an aneurysm needle is passed under the nerve, and the trunk is seized with artery forceps and divided about half an inch distal to the foramen. The periosteum is next raised from the floor of the orbit as far back as the entrance to the infra-orbital canal, and with a fine chisel the roof of the canal is removed until the nerve is freely exposed. By slowly twisting the forceps holding the divided end of the nerve and making gentle traction, the greater portion can be pulled away.

A considerable portion of both the proximal and distal ends may be avulsed, without opening up the canal, by grasping the nerve as it emerges from the foramen and very slowly rotating the forceps (Thierseh).

**Extra-cranial Division of Maxillary Nerve at Base of Skull.**—The relief afforded by resection of the nerve from its point of emergence at the foramen rotundum to its appearance on the face at the infra-orbital foramen is more certain and lasting than that obtained by avulsion, and is always called for if the neuralgia involves the posterior teeth.

*Koehler's Operation by Dislocation of the Malar Bone* (Figs. 46 and 47).—An incision, which falls as far as possible in the natural fold of the face, is made from a point about a quarter of an inch below the inner end of the

infra-orbital margin, obliquely downwards and outwards, so as to cross the lower part of the malar bone, then upwards and backwards as far as the zygoma. It is carried down to the bone, and the periosteum together

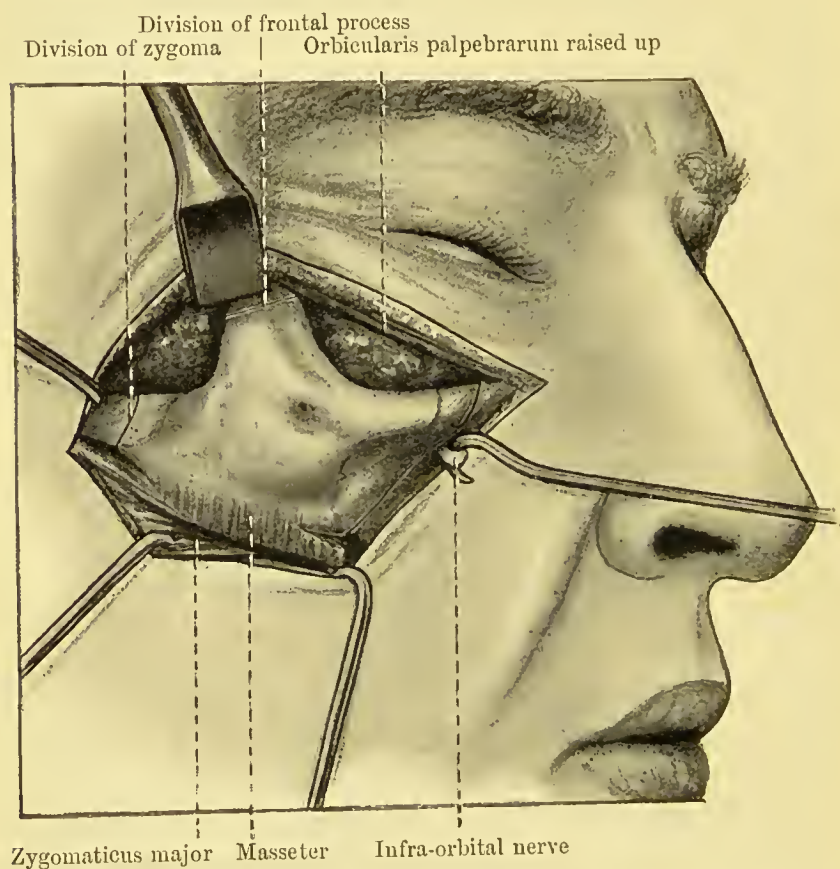


FIG. 46.—Extra-cranial Division of Maxillary Nerve, 1st Stage.

with the muscles—orbicularis palpebrarum, levator labii superioris, and zygomaticus major and minor, are raised upwards as far as the lower margin of the orbit, and downwards far enough to expose the nerve as it emerges from the infra-orbital foramen. The malar process of the maxilla and the malar bone are then thoroughly cleared.



With a strong chisel or Gigli saw the malar process of the superior maxilla is divided from above the infra-orbital nerve, downwards and outwards, to just below the anterior edge of the origin of the masseter, and then

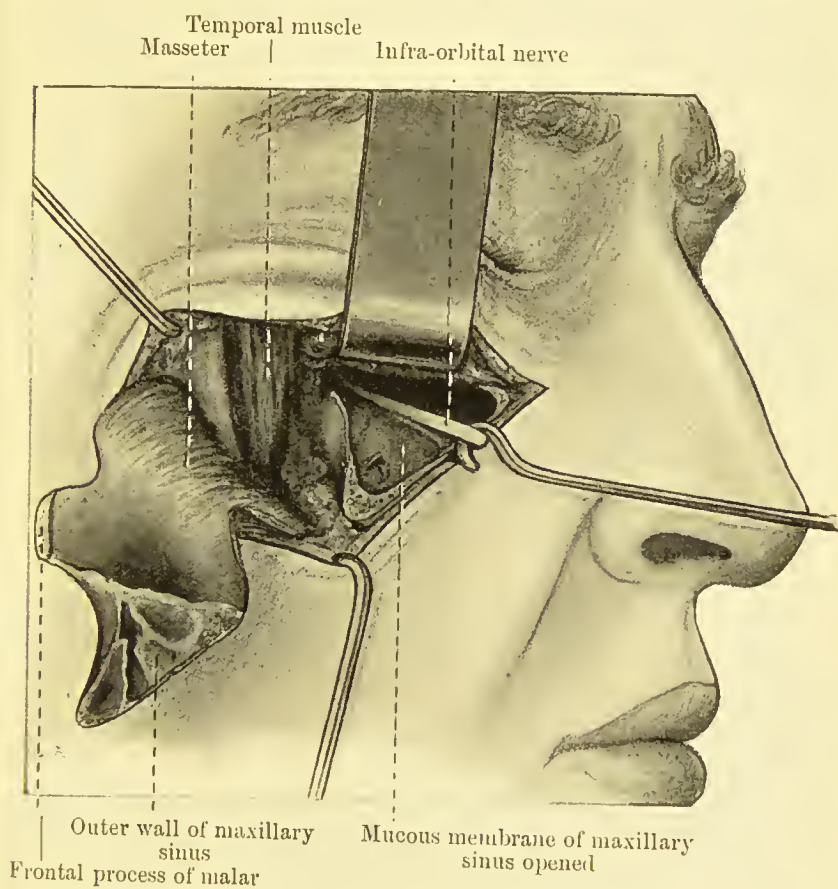


FIG. 47.—Extra-cranial Division of Maxillary Nerve, 2nd Stage.

upwards through the outer wall of the maxillary sinus. The fronto-malar suture and the zygoma are in turn chiselled or sawn across, and by traction made with a strong sharp hook the malar bone is dislocated downwards and outwards.

If traction is made upon the proximal end of the infra-orbital nerve after it has been divided, it can

be traced along the floor of the orbit and across the spheno-maxillary fossa as far as the foramen rotundum. The nerve is then raised by means of an aneurysm needle passed round it close to the foramen, and divided with curved scissors or avulsed. Meckel's ganglion comes away with the nerve. If the infra-orbital artery, which accompanies the nerve, is injured it must be twisted or tied. The bone is replaced in position without suturing, and the wound closed.

**MANDIBULAR OR INFERIOR MAXILLARY DIVISION.**—The third or mandibular branch of the trigeminal nerve differs from the ophthalmic and maxillary divisions in that it contains motor fibres, which supply the muscles of mastication. At the foramen ovale, where the nerve emerges from the skull, the motor and sensory fibres are so intimately associated that they cannot be divided separately, but experience has shown that section of the entire nerve is not followed by any appreciable impairment of mastication.

**Resection of the Inferior Dental (Inferior Alveolar) and Lingual Nerves by Trephining the Jaw.**—The inferior dental nerve is the larger terminal branch of the mandibular, and after passing between the ramus and the internal lateral (spheno-mandibular) ligament of the lower jaw it enters the inferior dental canal, along with the artery of the same name, and traverses the ramus and body of the lower jaw, supplying branches to the teeth and emerging on the face through the mental foramen as the mental nerve. The lingual nerve lies in front of the inferior dental, and, after passing between the internal pterygoid muscle and the ramus of the jaw, runs beneath the mucous membrane of the floor of the mouth to the side of the tongue and supplies the anterior two-thirds with sensation. These nerves may be exposed for purposes of resection either from the face or from the mouth.

A curved incision is made around the angle of the jaw, exposing the tendinous fibres of the masseter, which are divided and with the periosteum are displaced upwards sufficiently to expose the central part of the ramus (Fig. 48). With a  $\frac{1}{2}$ -inch trephine a circle of bone is

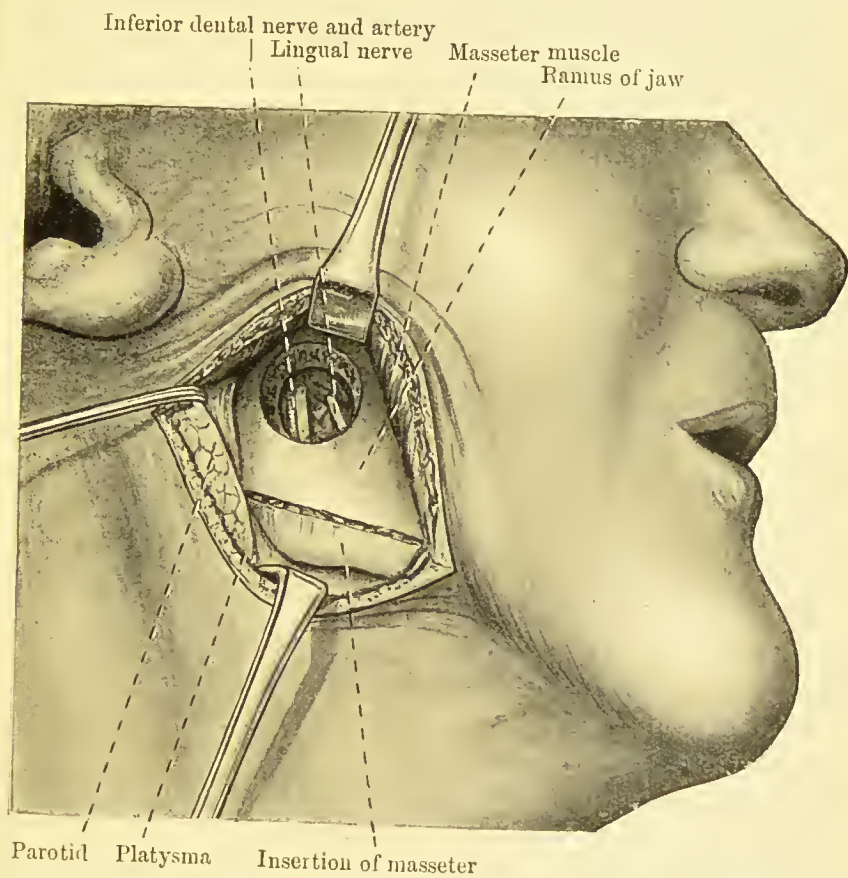


FIG. 48.—Resection of Inferior Dental and Lingual Nerves.

removed opposite the last molar tooth, and the nerve is exposed as it enters the inferior dental canal, with the lingual lying anterior to it. If necessary this opening can be enlarged with rongeur forceps. The nerves can then be resected or avulsed. The masseter is replaced and stitched in position, and the wound closed.

As the **mental branch** is seldom included in the portion avulsed, an incision should be made along the lower border of the jaw opposite the interval between the first and second bicuspid teeth, dividing the periosteum, which is stripped up until the foramen is reached. The nerve is then seized with forceps and avulsed. This branch can also be exposed by dividing the mucous membrane at its line of reflection opposite the interval between the first and second bicuspid teeth, and reflecting the periosteum downwards till the foramen is reached.

### **Resection of Inferior Dental Nerve from the Mouth.**

—The mouth is opened widely with a gag and a strand of silk-worm gut is passed through the body of the tongue to act as a retractor. An incision about an inch long is then made parallel with and posterior to the anterior border of the ramus, and the muco-periosteum separated backwards till the internal lateral ligament, which is attached to the inferior dental spine, is felt. This ligament is divided, and the nerve is isolated from its accompanying vessels with the aid of an aneurysm needle and resected or avulsed. The wound is allowed to heal by granulation, the mouth being kept clean by frequent spraying with peroxide of hydrogen and other mouth washes.

**Resection of the Lingual Nerve from the Mouth.**—If the tongue is grasped with forceps or transfixed with a strand of silk-worm gut, and pulled to the opposite side of the mouth, the nerve stands out as a cord beneath the mucous membrane of the tongue behind the last lower molar tooth, and can be exposed and resected through a short incision dividing the mucous membrane. This operation is seldom indicated.

**Auriculo - temporal Branch.** — The auriculo-temporal branch, after leaving the pterygo-maxillary space, passes upwards in company with the temporal artery through the substance of the parotid gland, and thence over the



zygoma to its distribution in the auricle and skin of the temporal region.

It is exposed by a vertical incision through the skin and superficial layer of the temporal fascia about a quarter of an inch in front of the tragus. The artery is first identified and the nerve sought for just behind it. The nerve should be secured close to the zygoma before it has given off its branches to the external auditory meatus and the pinna.

The **buccal branch**, which supplies the skin of the cheek and the mucous membrane in the region of the angle of the mouth, can be exposed from the interior of the mouth as it passes transversely across the coronoid process. The mouth is opened widely, the ridge at the anterior border of the ramus of the jaw felt for, and an incision made through the mucous membrane and the fibres of the buccinator muscle. When isolated the nerve is seized with forceps and avulsed.

It may also be exposed from without by an incision along the lower border of the zygoma, but this operation involves the risk of injuring the branches of the facial nerve.

**Extra-cranial Division of the Mandibular Division at Base of Skull.** — In *Kocher's Method* (Fig. 49) an incision is made from a point a finger's breadth behind the frontal process of the malar, obliquely downwards and backwards to the posterior extremity of the zygomatic arch, and thence upwards in front of the ear, at right angles to the first part of the incision. The temporal vessels are secured with forceps, the temporal fascia divided above the zygoma, and the periosteum cleared off the malar bone and zygoma. The malar is divided with the chisel or saw behind its frontal process and the zygoma close to its root. The whole arch is then pulled downwards, exposing the temporal muscle. To afford access the coronoid process is snipped across with



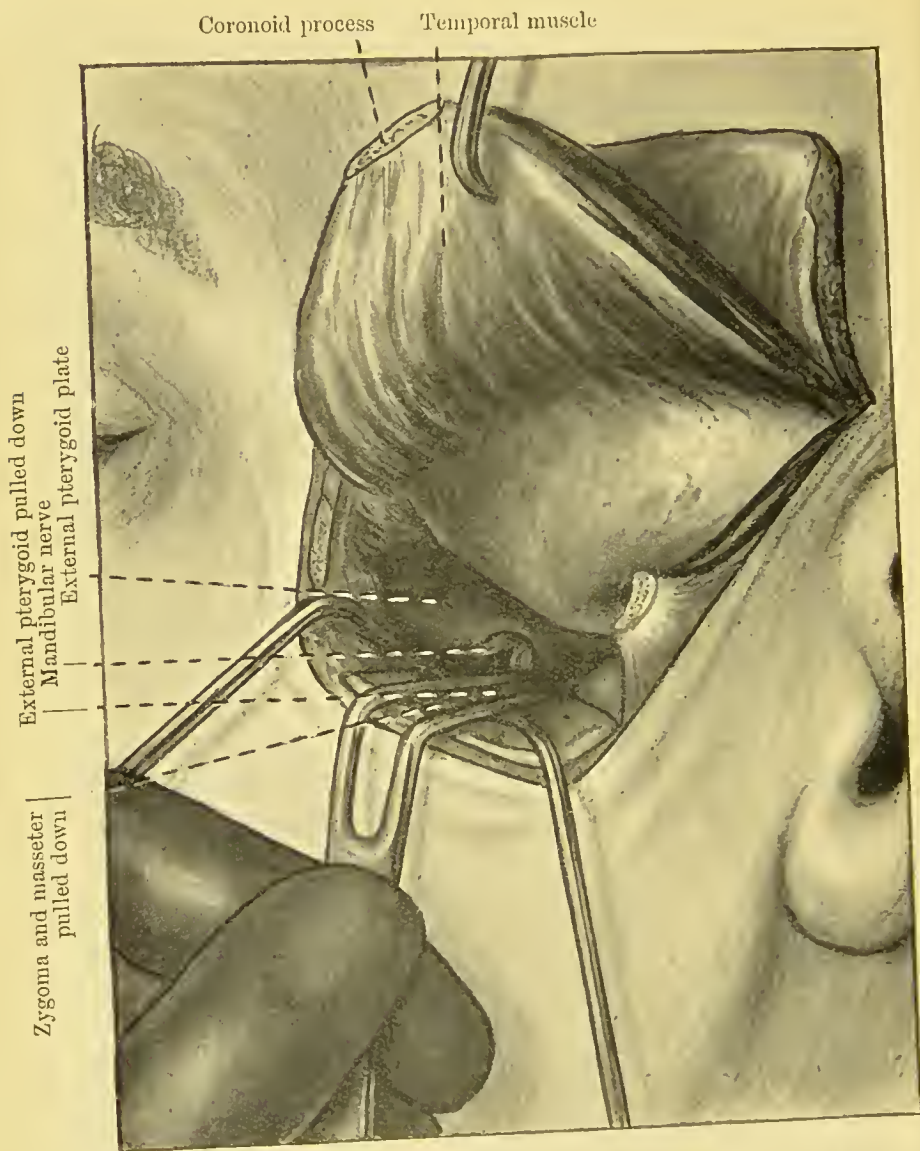


FIG. 49.—Extra-cranial division of Mandibular Nerve at Base of Skull.

bone pliers, and the temporal muscle retracted upwards. The outer aspect of the base of the pterygoid process is thus exposed, and the foramen ovale can be felt behind it about an inch from the root of the zygoma. The nerve is raised on an aneurysm needle and avulsed, care

being taken to avoid injuring the middle meningeal artery. The temporal muscle is then replaced, sutured in position, the zygoma similarly dealt with, and the wound closed.

**ANASTOMOSIS OF THE FACIAL AND HYPOGLOSSAL NERVES.**—In cases of persistent facial paralysis, resulting from disease of the middle ear or from other causes, function may be to some extent restored by establishing a communication between the distal end of the nerve and the intact hypoglossal nerve.

Facio-hypoglossal anastomosis has almost entirely superseded the junction of the facial and spinal accessory nerves, as after this operation voluntary movements of the shoulder are liable to be accompanied by undesirable contractions of the facial muscles.

The *facial nerve*, after traversing the internal auditory meatus and the aqueduct of Fallopius (facial canal), emerges through the stylo-mastoid foramen, which lies at a distance of nearly an inch from the surface. It then runs forwards and slightly downwards along the upper border of the posterior belly of the digastric, and, after giving off the posterior auricular nerve and twigs to the stylo-hyoid and posterior belly of the digastric, enters the substance of the parotid gland. Opposite the posterior border of the lower jaw, at the level of the lower margin of the tragus, it divides into two main branches, the temporo-facial and cervico-facial, and these in turn subdivide to form a fine network of nerves—the pes anserina or parotid plexus, which supplies the muscles of expression.

The *hypoglossal nerve* leaves the skull through the anterior condylic foramen. In its course down the neck towards the hyoid bone it crosses the external carotid, hooking round its occipital branch, and then passes beneath the digastric and stylo-hyoid muscles. Above the great cornu of the hyoid bone it passes between the

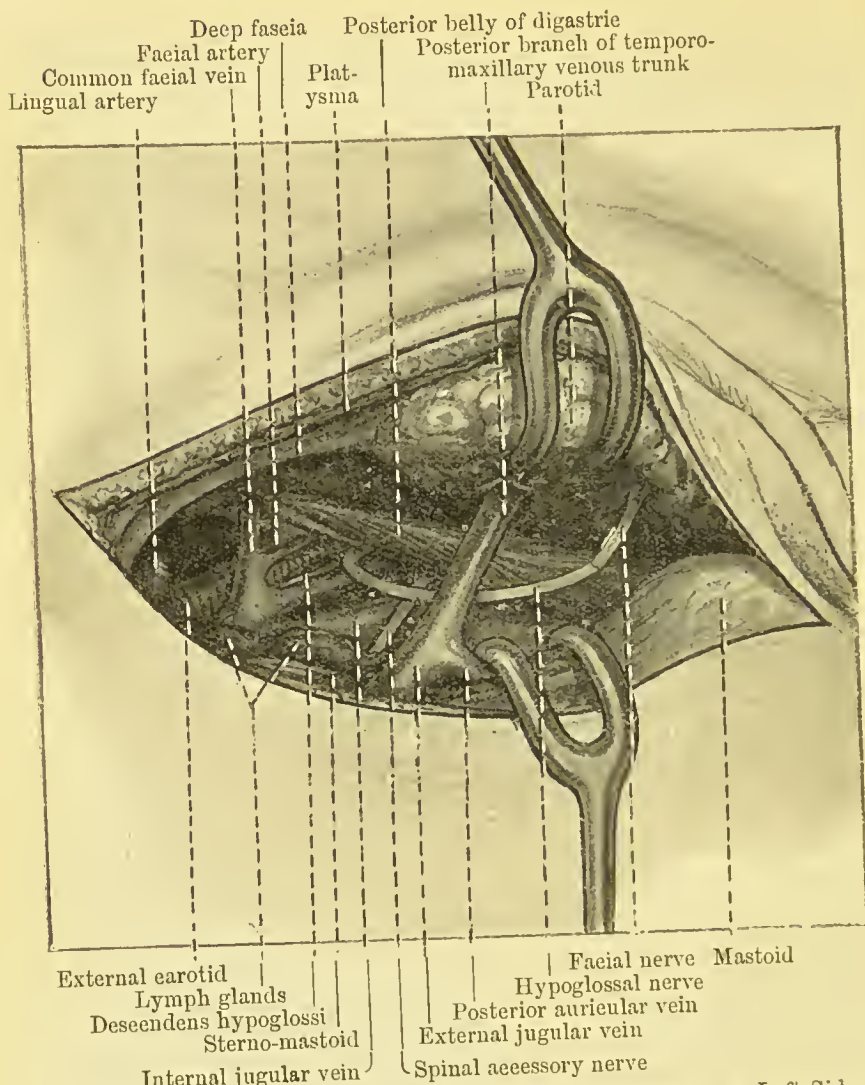


FIG. 50.—Anastomosis of Facial and Hypoglossal Nerves on Left Side.  
(The hypoglossal has been completely divided.)

mylo-hyoid and hyoglossus muscles to end in the muscular substance of the tongue.

**The Operation** of anastomosing these two nerves is performed through an oblique incision, similar to that employed for ligation of the external carotid, but at a slightly higher level (Fig. 50). To afford free

access, a short horizontal incision may be made, passing forward from the centre of this incision to the angle of the jaw. The integument having been divided and the strong fascia incised, the sterno-mastoid is cleared and retracted backward, and the lobules of the parotid gland are defined and pulled forward. In the space between these the posterior belly of the digastric appears, and after its upper border has been defined the facial nerve is found above it. The nerve can sometimes be distinguished from other structures by the fact that the facial muscles contract when it is stimulated. The nerve is raised on an aneurysm needle, traced back to the stylo-mastoid foramen, and cut across close to its point of exit.

In the lower part of the incision the hypoglossal nerve is dissected out as it emerges from beneath the posterior belly of the digastric and the stylo-hyoid muscles, the guide to the nerve being the occipital artery, round which it hooks at this level. It is traced upwards beneath the digastric, this muscle as well as the stylo-hyoid being divided if necessary to afford sufficient access. The nerve is partly cut across, and the distal end of the facial is brought to it and implanted among the nerve fibres. It is not necessary to divide the hypoglossal completely. To prevent blood collecting in the vicinity of the anastomosis and leading to the formation of cicatricial tissue, the wound should be drained.

**ANASTOMOSIS OF THE FACIAL AND SPINAL ACCESSORY NERVES.**—This operation has almost entirely been superseded by facio-hypoglossal anastomosis, as it is not so easy to perform, and is liable to be followed by involuntary movements of the face occurring in association with the movements of the shoulder.

The operation is similar to that for facio-hypoglossal anastomosis, the spinal accessory being secured as it emerges from beneath the posterior belly of the digastric and crosses the transverse process of the atlas vertebra.



**Stretching the Facial Nerve for Facial Spasm.**—The nerve is exposed through an incision similar to that employed for anastomosis. An aneurysm needle is passed round the nerve, and gentle traction is made on it sufficient to produce a partial but not a complete

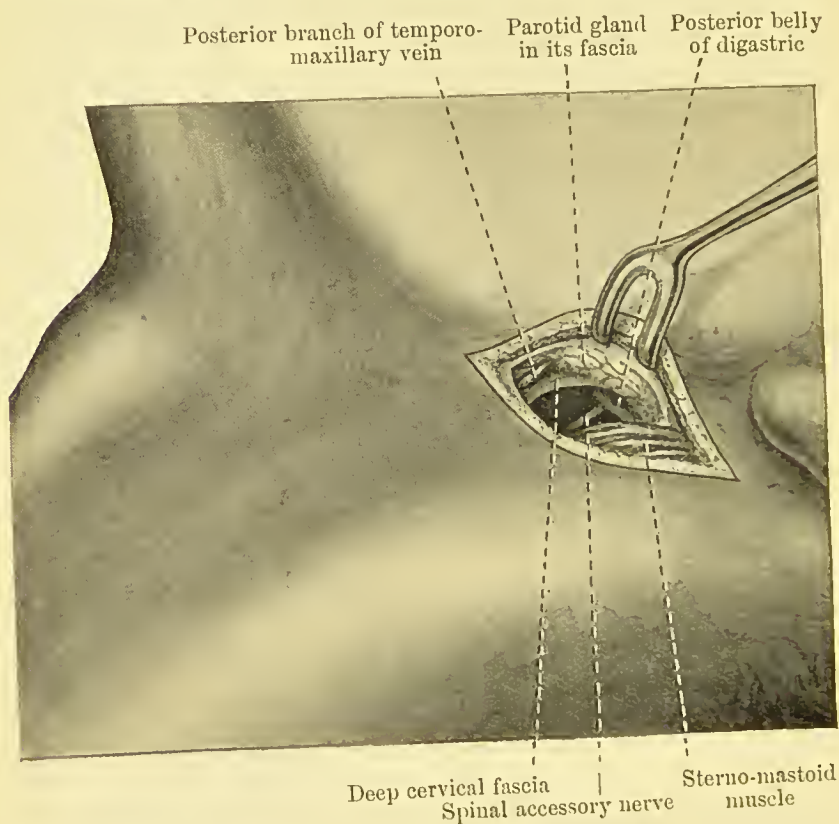


FIG. 51.—Exposure of Spinal Accessory Nerve.

paresis of the muscles. The amount of traction permissible is best estimated if the operation is performed under local anæsthesia. The paresis gradually passes off and the spasms are usually arrested, but the relief is not always permanent.

**EXPOSURE OF THE SPINAL ACCESSORY NERVE.**—The spinal accessory nerve passes downwards and backwards



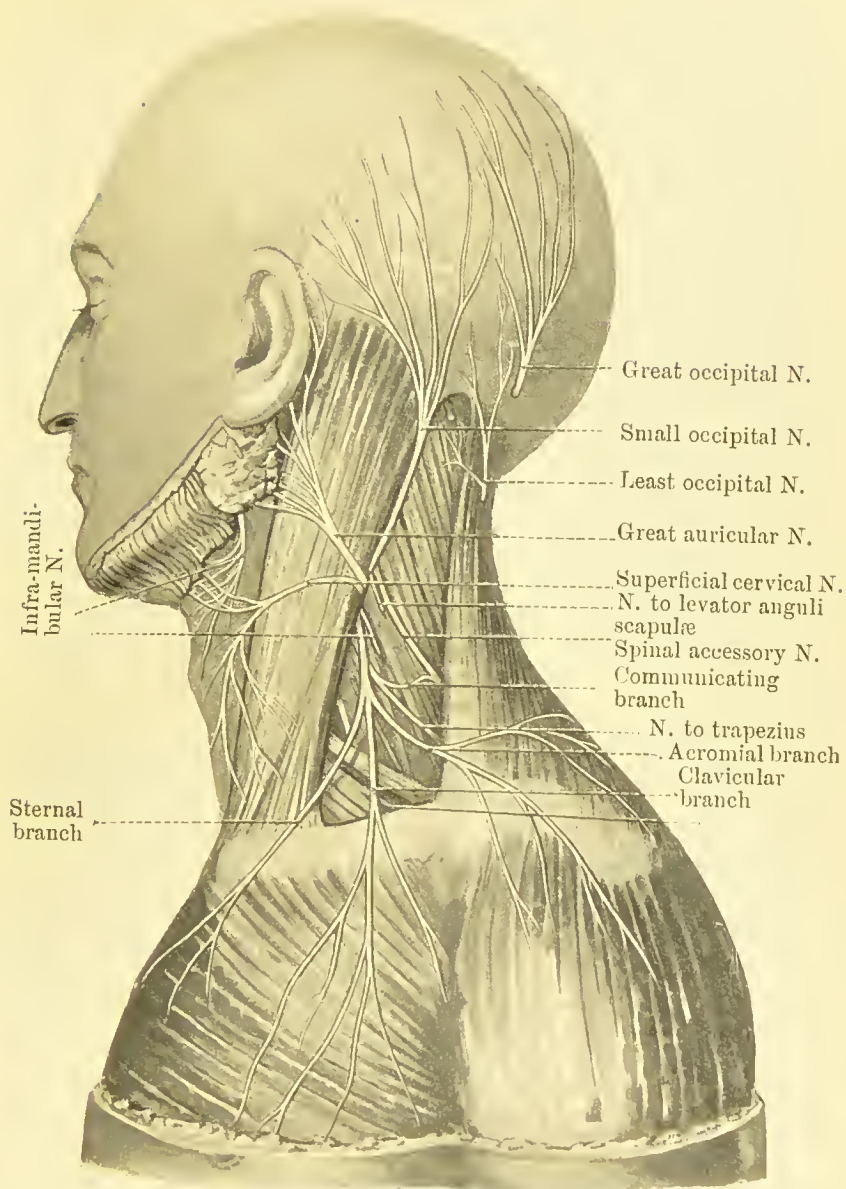


FIG. 52.—Dissection of Superficial Cervical Nerves.

in front of the transverse process of the atlas and the internal jugular vein, and enters the under surface of the sterno-mastoid muscle from an inch to an inch and

a half below the tip of the mastoid process. Its course is indicated by a line drawn from a point midway between the tip of the mastoid process and the angle of the lower jaw to the middle of the posterior border of the sterno-mastoid, and thence across the posterior triangle to the anterior border of the trapezius at the junction of its middle and lower thirds.

To expose the nerve, an incision is made from the apex of the mastoid process downwards and forwards parallel with the border of the lower jaw. The external jugular vein and the great auricular nerve having been isolated and the sterno-mastoid drawn backwards, the lower margin of the posterior belly of the digastric is defined, and the nerve is found emerging from under it and passing to enter the deep surface of the sterno-mastoid (Fig. 51).

For the relief of spasmodic wry-neck a portion, at least one inch in length, is resected in front of the sterno-mastoid.

If it is desired to establish an anastomosis with the facial nerve the spinal accessory is traced as far back as possible, the digastric and styloid muscles being divided if necessary.

To expose the nerve after the branch to the sterno-mastoid has been given off an oblique incision should be made with its centre over the posterior border of the middle third of the muscle (Fig. 52).

## CHAPTER VIII

### OPERATIONS ON SPINAL NERVES

#### RESECTION OF POSTERIOR PRIMARY DIVISIONS OF CERVICAL NERVES.

EXPOSURE OF BRACHIAL PLEXUS IN NECK. NERVES OF UPPER EXTREMITY : Circumflex — Median : *In upper arm ; In antecubital space ; In front of wrist*—Ulnar : *In upper arm ; Behind elbow ; In lower third of forearm*—Radial—Musculo-spiral : *In upper third of arm ; On posterior surface of arm ; On outer aspect of arm*—Musculo-cutaneous : *In upper part of arm ; Below middle of arm.* NERVES OF LOWER EXTREMITY : Great Sciatic—*At exit from pelvis ; In upper part of thigh ; In middle of thigh*—External Popliteal—Internal Popliteal—Anterior and Posterior Tibial—Anterior crural—External cutaneous

#### RESECTION OF THE POSTERIOR PRIMARY DIVISIONS OF THE CERVICAL NERVES

IN severe cases of spasmodic wry-neck, resection of portions of the spinal accessory nerve on one side, and of the posterior primary divisions of the first five cervical nerves on the opposite side, seems to offer the best prospect of recovery.

The posterior primary divisions of the cervical nerves form the posterior cervical plexus, from which are supplied the muscles of the back of the neck. The first (sub-occipital) lies in the suboccipital triangle below and behind the vertebral artery. The second emerges between the atlas and axis, and, after piercing the complexus and trapezius muscles, passes upwards to the scalp as the great occipital nerve, in company with the occipital artery. It is the principal cutaneous nerve to

the posterior portion of the scalp. The remaining nerves are smaller, and each divides under cover of the complexus into external muscular and internal cutaneous branches.

**Operation.**—To expose these nerves a vertical incision about four inches in length is made in the middle line of the neck from a point about half an inch below the external occipital protuberance, and from each end of this a transverse incision is carried outwards. The rectangular flap thus formed is reflected outwards, and after the posterior edge of the sterno-mastoid has been defined, and the trapezius and the oblique fibres of the splenius divided, the great occipital nerve is found as it emerges from the complexus. This muscle having been divided transversely, the nerve is seen curving round the lower border of the obliquus inferior, and is traced back to the posterior primary division. To reach the suboccipital triangle, the obliquus inferior, the rectus capitis posterior major, and the obliquus superior are defined, and the suboccipital nerve is resected as far back as possible, care being taken to avoid the vertebral artery. By following the communicating loops which pass from one to another, the remaining branches are then traced out beneath the complexus and resected.

The divided muscles are sutured in layers, and the wound is closed.

**EXPOSURE OF BRACHIAL PLEXUS IN NECK.**—Access to the cords of the plexus is obtained by a dissection similar to that employed for ligation of the third part of the subclavian artery (p. 19). After the deep fascia has been divided and the omo-hyoid retracted upwards, the cords are sought for as they emerge from under cover of the scalenus anterior, and are traced downwards until the seat of the lesion is found. In the case of the first dorsal nerve it may be necessary temporarily to resect the clavicle to obtain satisfactory access.

If one or more of the cords have been torn, the ends must be brought into apposition and sutured. If the divided ends are buried in cicatricial tissue they must be freed and then united. If the inner cord is pressed upon by a cervical rib, this is resected together with its periosteum sufficiently freely to relieve the pressure. In cases of paralysis of the Erb-Duchenne type, occurring in infants (*brachial birth palsies*), the cords are occasionally completely torn, and the reaction of degeneration is present. In such cases the nerves should be exposed and sutured.

### OPERATIONS ON NERVES OF THE UPPER EXTREMITY

CIRCUMFLEX (AXILLARY) NERVE.—To expose the circumflex nerve a linear incision is made on the back of the limb in the groove formed by the posterior border of the deltoid and the posterior scapular muscles, dividing the integument and deep fascia which is closely adherent to the deltoid. The deltoid is then pulled forward, and the tendons of the teres minor and long head of the triceps brought into view. In the angle between the teres minor and the neck of the humerus the circumflex nerve emerges, accompanied by the posterior circumflex artery, and, passing round the back of the humerus, it enters the under surface of the deltoid.

MEDIAN NERVE.—The operations for exposing the median nerve, either *in the upper arm* or *in the antecubital fossa*, are the same as those for ligation of the corresponding parts of the brachial artery (pp. 41 and 42). In the upper part of the limb the nerve lies to the outer side of the artery, about the middle of the upper arm it crosses the vessel obliquely, and in the lower part lies to the inner side. At the bend of the elbow the nerve is about a quarter of an inch inside the artery, lying to



the outer edge of the pronator radii teres. In the upper arm it gives off no branches.

It is often necessary to expose the median nerve just *above the wrist* in order to repair damage sustained by an accidental wound in this region (Fig. 53). An incision is made over the radial border of the palmaris longus tendon, a finger's breadth above the transverse skin fold,

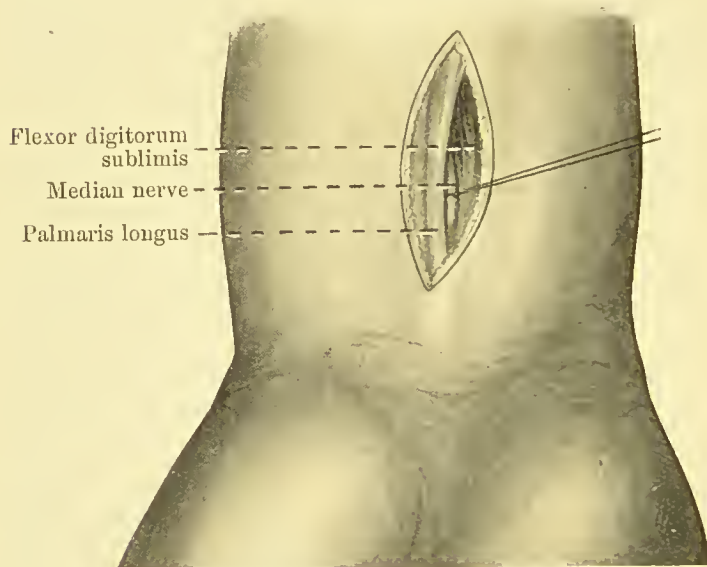


FIG. 53.—Exposure of Right Median Nerve above Wrist.

which indicates the position of the upper edge of the anterior annular ligament. On entering the inter-muscular septum between the palmaris longus and the flexor carpi radialis, the nerve is found either between these tendons or under cover of the palmaris longus. Its size may lead to its being mistaken for a tendon, but its darker colour and feathered appearance serve to distinguish it.

**ULNAR NERVE.**—The ulnar nerve may be exposed *above the middle of the upper arm* by an incision parallel

with, and half an inch internal to, the line of the artery. In this part of its course it is accompanied by the inferior profunda vessels.

To expose it *behind the elbow*, the incision is made in the sulcus between the olecranon process and the internal epicondyle. After the skin and fascia have been divided the nerve, accompanied by the inferior profunda artery, is found lying close to the bone along the inner edge of the triceps. At the lower border of the epicondyle it passes between the two heads of origin of the flexor carpi ulnaris, and comes to lie on the flexor digitorum profundus. It gives off no branches in the upper arm.

In the *lower two-thirds of the forearm* the ulnar nerve runs to the ulnar side of the artery of the same name, and may be exposed by an operation similar to that performed for ligation of the artery (p. 47).

The RADIAL NERVE in the middle third of the forearm is exposed by the same operation as for ligation of the corresponding part of the radial artery (p. 44).

MUSCULO-SPIRAL (RADIAL) NERVE. — This nerve, the continuation of the posterior cord of the brachial plexus, in the upper third of the arm lies behind the brachial vessels, and, with the superior profunda artery, winds down the back of the humerus in the musculo-spiral groove, crossing the bone from within outwards. On reaching the outer aspect of the limb it pierces the external inter-muscular septum at the junction of the upper and middle thirds of a line drawn from the deltoid insertion to the external epicondyle. It then descends between the brachio-radialis (supinator longus) and brachialis anticus muscles as far as the level of the external condyle, where it divides into the radial (ramus superficialis) and the posterior interosseous nerves.

Above the point where it pierces the inter-muscular

septum it gives *branches* to supply the different heads of the triceps and the anconeus, as well as external and internal cutaneous branches. After it has pierced the septum it supplies the brachio-radialis (supinator longus), the brachialis anticus, the extensor carpi radialis longior (sometimes also the brevior), and the elbow-joint.

As this nerve is liable to be involved in cases of

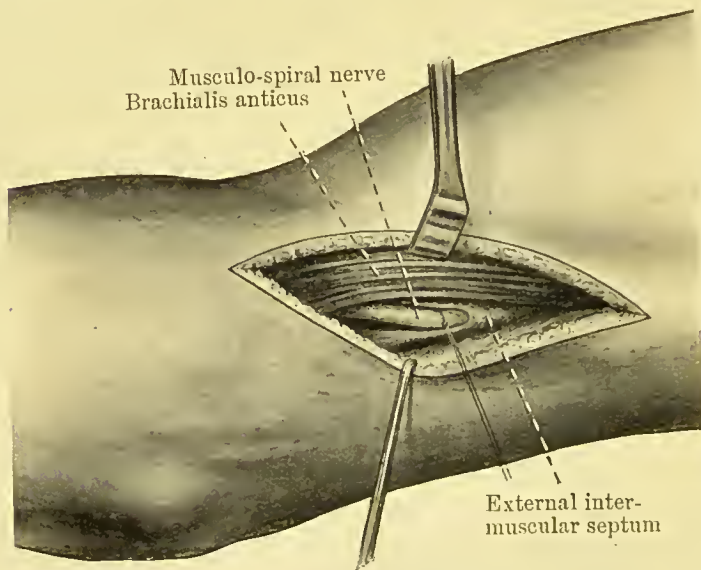


FIG. 54.—Exposure of Left Musculo-spiral Nerve on Outer Aspect of Limb.

fracture of the shaft of the humerus it is often necessary to expose it by operation.

To reach the nerve **in the upper third of the arm**, an incision is made as for ligation of the third part of the axillary artery (p. 38), the deep fascia divided, and the lower border of the latissimus dorsi tendon defined. The nerve is found lying on the latissimus dorsi and behind the superior profunda artery.

To expose the nerve as it passes across the **posterior surface of the arm**, an incision is curved downwards from

a point a finger's breadth behind the deltoid insertion towards the tip of the olecranon process. After dividing the deep fascia, the long and outer heads of the triceps are separated down to the bone and the nerve is found in the musculo-spiral groove.

To expose the nerve near its bifurcation on the **outer aspect** of the limb and after it has pierced the inter-muscular septum, the elbow is flexed and the forearm laid across the chest. An incision is made in the external bicipital sulcus, its centre corresponding to a point midway between the deltoid insertion and the external epicondyle, and its lower part following the obliquity of the inner border of the brachio-radialis (supinator longus) (Fig. 54). In the superficial fascia the cephalic vein is exposed, and drawn aside; the deep fascia is then divided and the interval between the brachio-radialis and brachialis anticus muscles opened up. If the brachio-radialis is now drawn outwards, the nerve is found on the anterior aspect of the humerus.

**MUSCULO-CUTANEOUS NERVE.**—In the upper arm this nerve gives off muscular branches to the coraco-brachialis, the two heads of the biceps, and the brachialis anticus. Below the elbow it supplies cutaneous branches to the front and back of the radial aspect of the forearm.

**In the upper part of the arm** it may be exposed by an operation similar to that for ligation of the third part of the axillary artery (p. 38). The nerve lies to the outer side of the vessel, and may be seen entering the coraco-brachialis muscle.

**Below the middle of the upper arm,** the incision is made at the outer side of the biceps, care being taken to avoid the cephalic vein. After dividing the fascia, the biceps is raised from the brachialis anticus, and the nerve is found under the thin fascia which covers this muscle.

## OPERATIONS ON NERVES OF THE LOWER EXTREMITY

**GREAT SCIATIC NERVE (NERVUS ISCHIADICUS).**—This nerve emerges from the pelvis through the great sacro-

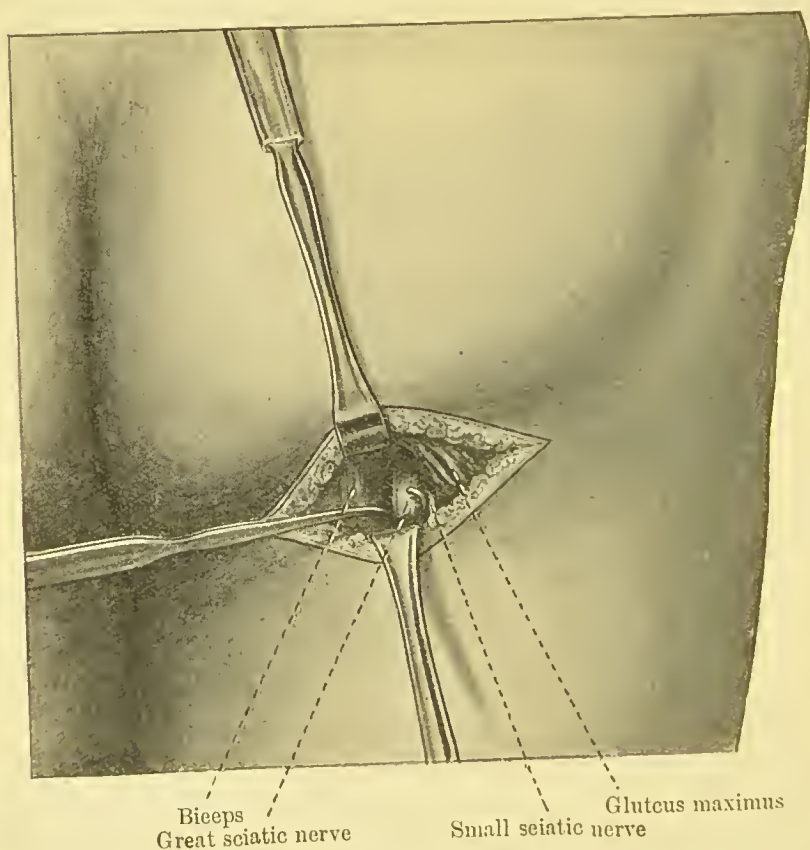


FIG. 55.—Exposure of Right Great Sciatic Nerve at the fold of the Buttock.

sciatic foramen below the piriformis, and after passing through the buttock, enters the back of the thigh beneath the fold of the nates at a point midway between the ischial tuberosity and the posterior edge of the great trochanter. It forms a broad nervous band which usually comprises



the nerves to the hamstring muscles and to the short head of the biceps, as well as the internal popliteal (tibial) and external popliteal (peroneal) nerves, enclosed in a common sheath. The nerve terminates at a variable level by dividing into the internal and external popliteal nerves, the internal continuing its straight course to the popliteal space, while the external passes outwards under cover of the biceps to reach the back of the upper end of the fibula. Sometimes these two trunks are separate throughout their whole course. After emerging from under cover of the gluteus maximus muscle, the great sciatic trunk lies upon the adductor magnus and beneath the hamstring muscles.

**At its exit from the pelvis** through the lower part of the great sciatic foramen, the nerve is exposed by the same operation as for ligation of the sciatic artery (p. 53). It lies against the base of the spine of the ischium on a deeper plane than the artery and smaller sciatic nerve, which are to its inner side.

To expose the nerve **in the upper part of the thigh**, an incision is made in the line of the gluteal fold, dividing the integument and deep fascia. The gluteus maximus having been exposed and pulled upwards, the outer edge of the biceps is seen running obliquely downwards and outwards with the small sciatic over it. If the surgeon, standing on the opposite side of the patient, now passes his left forefinger under the biceps, he can readily feel the nerve as it lies in a mass of coarse fat and hook it up (J. Chiene). It is accompanied by the *comes nervi ischiadici* artery and vein.

To stretch the nerve, one or two fingers are passed under it, and steady traction, without jerking, is made upon it in both directions until it is quite slack. The nerve will stand as much traction as can be put upon it without jerking. It is then replaced in its bed, and the wound closed without drainage. If the nerve has

already divided at the level at which it is exposed, both branches must be stretched.

**In the middle of the back of the thigh**, the nerve can be easily exposed through a longitudinal incision in the middle line placed between the biceps on the outer side and the semi-tendinosus and semi-membranosus on the inner. After the integument has been divided, the small sciatic nerve is sought for, either on or under the deep fascia, and is hooked aside. The inter-muscular septum is then opened up and the great sciatic as a single trunk or after having divided into external and internal popliteal is found lying on the posterior surface of the femur.

**THE EXTERNAL POPLITEAL (COMMON PERONEAL) NERVE**—one of the divisions of the great sciatic—runs under cover of the biceps across the upper and outer part of the popliteal space, and after passing over the outer head of the gastrocnemius, reaches the back of the head of the fibula and terminates about one inch lower down under cover of the peroneus longus by dividing into the anterior tibial (deep peroneal), musculo-cutaneous (superficial peroneal), and recurrent tibial nerves.

To expose the nerve, an incision is made along the posterior edge of the biceps tendon from the prominence of the external condyle to the posterior border of the head of the fibula. After the deep fascia is divided, the tendon is displayed, and the nerve is found under cover of it and near the outer edge of the gastrocnemius (Fig. 56).

The operation for exposing the **internal popliteal (tibial) nerve** is the same as that for ligation of the lower part of the popliteal artery (p. 61).

The **anterior and posterior tibial nerves** are exposed by the same operations as for ligation of the corresponding arteries (pp. 63, 67).

**ANTERIOR CRURAL (FEMORAL) NERVE.**—To expose the anterior crural nerve an incision is made just below and

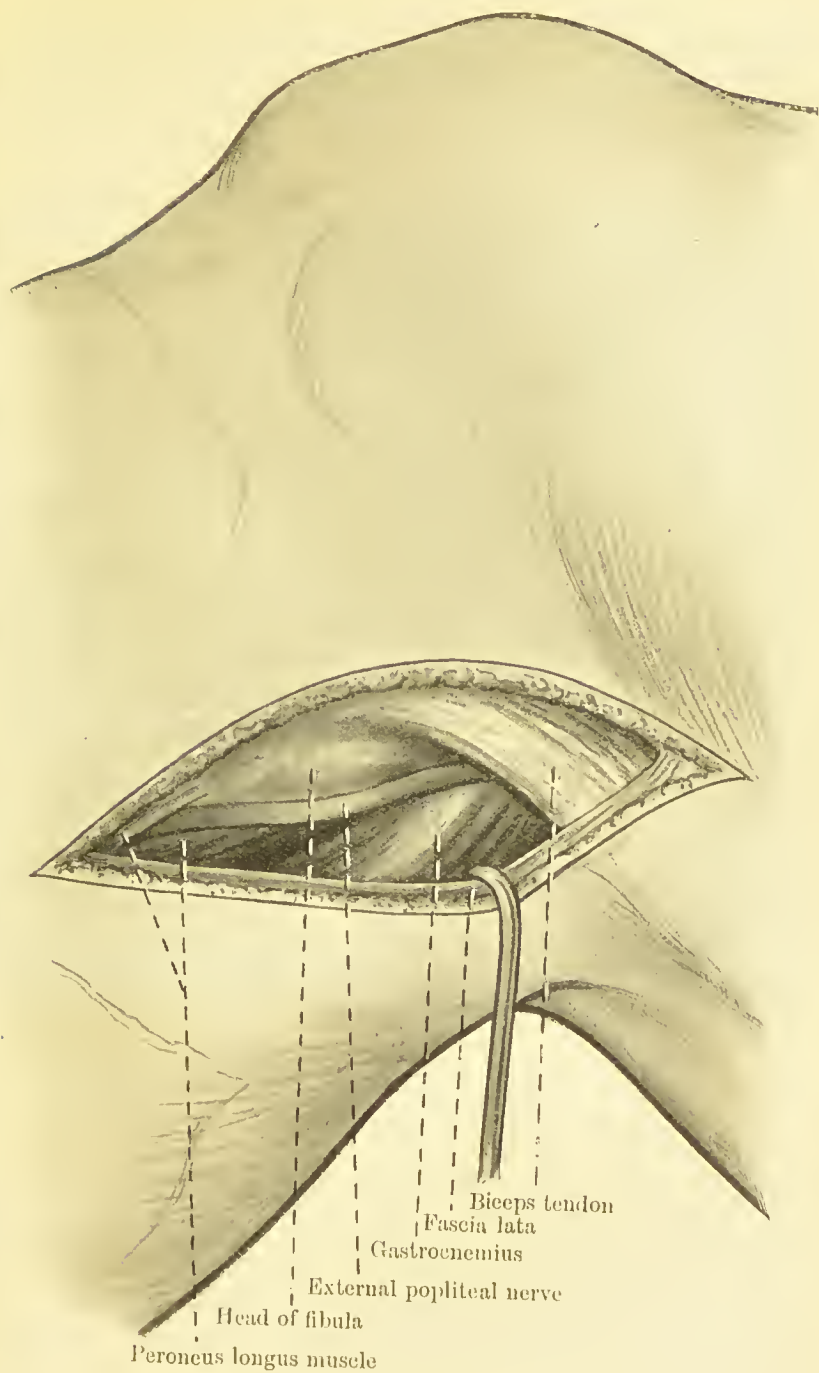
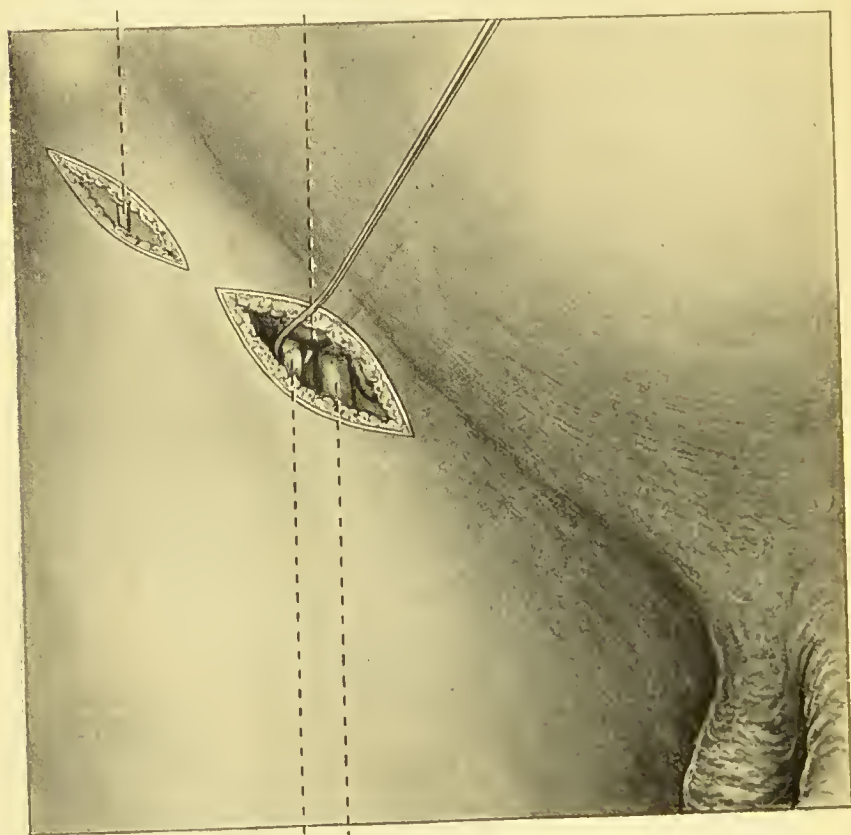


FIG. 56.—Exposure of Left External Popliteal Nerve.

parallel with the middle third of Poupart's ligament. After the fascia lata and the sheath of the ilio-psoas have been divided, the nerve is found in the groove between

External cutaneous nerve      Superficial inguinal gland



Anterior crural nerve      Femoral artery in sheath

FIG. 57.—Exposure of Right Anterior Crural and External Cutaneous Nerves.

the two portions of the ilio-psoas muscle, the fibres of the psoas separating it from the femoral artery (Fig. 57). In the upper part of Scarpa's triangle, it breaks up into its branches, which supply the pectineus, sartorius, and quadriceps extensor muscles, and the skin on the front of the thigh.

EXTERNAL (LATERAL) CUTANEOUS NERVE.—This nerve supplies the skin on the outer side of the thigh as far as the knee. It may be exposed through an incision parallel with Poupart and a finger's breadth below the anterior superior iliac spine, where it runs in a downward and outward direction under the deep fascia near the outer edge of the sartorius (Fig. 57).



## CHAPTER IX

### OPERATIONS ON THE BONES

FRACTURES : Recent Simple Fractures—Recent Compound Fractures—Badly United Fractures—Delayed Union and Want of Union. INDIVIDUAL FRACTURES : Neck of Femur—Shaft of Femur—Transverse fracture of Patella—Both bones of Leg—Clavicle—Upper end of Humerus—Neck of Humerus complicated with dislocation of shoulder—Shaft of Humerus with implication of Musculo-spiral Nerve—Lower end of Humerus—Olecranon Process of Ulna—Bones of Forearm. OSTEOTOMY : For Knock-knee and Bow-knee—Linear Osteotomy—Cuneiform Osteotomy—*Open Operation*—Genu Varum—Osteotomy of Tibia—Osteotomy of Upper End of Femur—Division of narrow part of Neck of Femur (Adam's Operation)—Osteotomy below the Trochanters—Trans-trochanteric Osteotomy—Lengthening of Bones in Shortened Limbs—Sub-periosteal Resection of a Long Bone—Resection of a Long Bone with the Periosteum

### OPERATIONS UPON RECENT SIMPLE FRACTURES

IN our opinion operative treatment in simple fractures of the shafts of long bones is only called for when it is evident that the fragments cannot otherwise be brought into sufficiently accurate apposition to avoid such shortening or deformity as will interfere with the function of the limb ; or when it is found to be impossible to maintain them in good position by other means.

In fractures implicating articular surfaces, the difficulty of replacing the fragments and maintaining them in accurate apposition, and the risk of impaired mobility

of the joint after faulty coaptation, necessitate more frequent recourse to immediate operation.

Before operation is decided upon, the position of the fragments should be determined by means of a series of X-ray photographs taken from different aspects, or preferably by stereoscopic plates. After this information has been obtained, a further attempt at reduction should

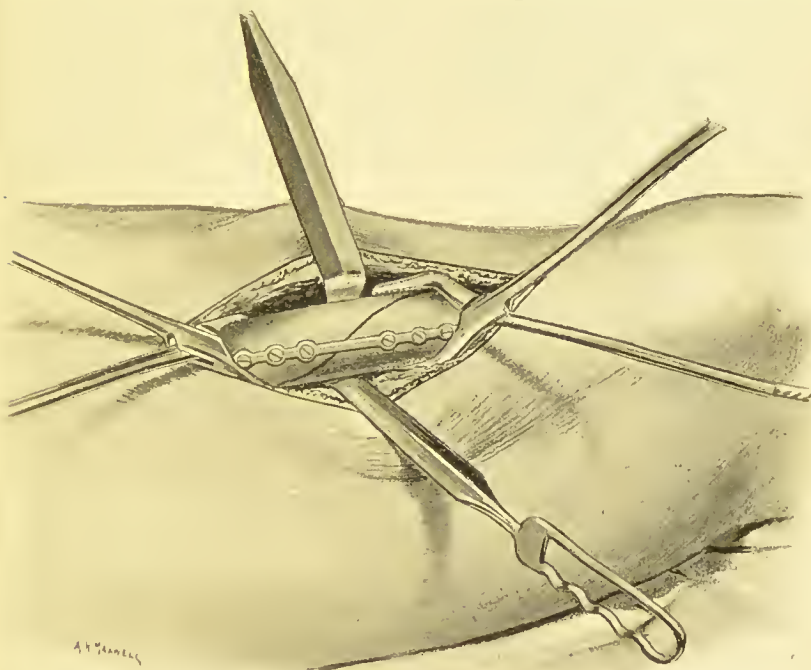


FIG. 58.—Fragments of Femur held by gripping forceps and plated by Lane's Method.

be made under anæsthesia, and the effect observed by the screen or skiagram. If the result is still unsatisfactory, operative treatment is indicated.

Arbuthnot Lane advocates operating within two or three days of the injury, but with the majority of surgeons we prefer to wait for a week or ten days until the tissues have partly recovered from the trauma of the accident.

The seat of fracture is exposed by an incision so

placed as to give the best access to the broken bones with the minimum disturbance of the soft parts, special care being taken to avoid injuring motor nerves. All the manipulations should be made with instruments, preferably with long handles, so that the risk of contact

infection from the hands may be reduced to a minimum. It is to be borne in mind that the bruised condition of the parts renders them specially susceptible to infection. The obstacle to reduction

having been removed, the fragments are brought into apposition by traction on the distal part of the limb, carried out by an assistant, combined with leverage effected with powerful long-handled bone grippers—a step in the operation which involves the expenditure of considerable time and patience.

If the fracture is transverse and the ends of the bones broad, there may be little or no tendency to re-displacement after they have once been placed in apposition, and it is not necessary to employ any mechanical means of fixation. The wound is then closed and the limb fixed in a suitable splint. In the great majority of cases calling for operative treatment, however, the

fragments can only be retained in apposition by mechanical means. Silver wire sutures, long steel pins driven through both fragments (Fig. 61), metal staples or screws and various other appliances are available to meet the requirements of individual cases. Sometimes a rod of bone or

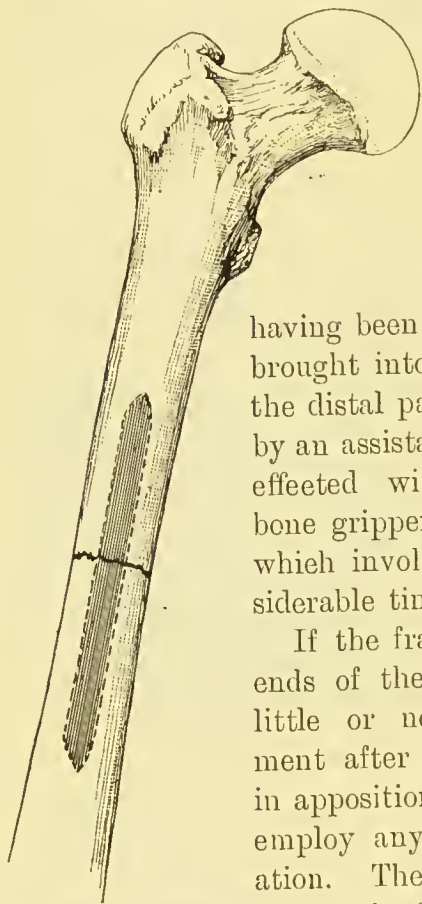


FIG. 59.—Medullary Pin or Peg.

ivory is pushed into the medullary canal of each fragment and acts as an internal or "medullary" splint (Fig. 59). The most generally useful support for the fragments is a steel plate, such as is employed by Arbuthnot Lane, the pioneer of this method of treatment. The plates are of different sizes and shapes, and are fixed by plated screws with a cylindrical shank (Fig. 58). The instruments devised by Lane and by Lambotte for the different steps of the operation can be strongly recommended.

After the fragments have been brought into apposition, they are held absolutely rigid by means of bone grippers, and a suitable plate having been applied to the aspect of the bone which is best covered with soft tissues, the holes are drilled in the bone and the screws, held with a special forceps, are driven firmly home. More than one plate may be required to secure perfect rigidity. The soft parts are replaced and the wound closed, with or without drainage.

OPERATIONS FOR COMPOUND FRACTURES.—In cases of compound fracture, once it has been decided that an attempt should be made to save the limb, the operative treatment is more a question of wound technique and the maintenance of asepsis than of the actual treatment of the broken bone. If the conditions are such as will permit of asepsis, advantage may be taken of the open wound to fix the fragments together by plates or other appliances. Steel pins pushed through the fragments from the overlying skin present this great advantage in compound fractures, that should the asepsis not be absolute, they can be withdrawn after their purpose has been fulfilled, and sufficient callus has formed to maintain the fragments in position, usually at the end of three or four weeks.

OPERATION FOR BADLY UNITED FRACTURE.—Operation may be required in mal-united fracture because the fragments are united in a faulty position, or to remove excess of callus which interferes with the free action of the muscles.

When the fragments have united at an angle and there is not much shortening, the fracture should be reproduced by an oblique osteotomy, so planned that the limb can be straightened, and, by sliding the divided surfaces on one another, such shortening as exists may be remedied. The fragments having been brought into line, are plated by Lane's method.

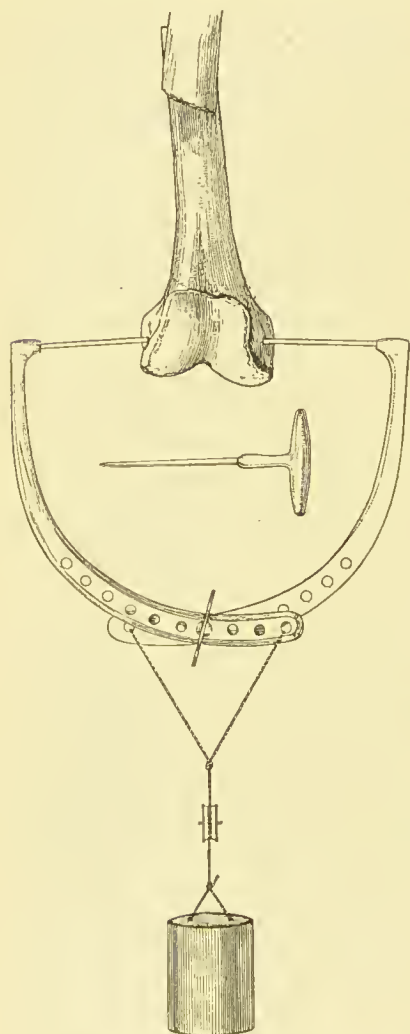


FIG. 60.—Steinmann's Apparatus for Direct Extension. The pin should be inserted obliquely downwards into the bone.

When the fragments override one another and there is considerable shortening, in addition to performing an oblique osteotomy, it is usually necessary to deal with the contracted soft parts before the contour of the bones can be restored and the shortening corrected. Tendons must be divided or lengthened, and contracted fasciæ cut across. Forceful traction must then be made on the distal segment of the limb, by means of a clove-hitch thrown round the ankle or wrist. In the lower extremity where there is

often great difficulty in making efficient traction, Steinmann's plan of applying the traction directly to the distal segment of the bone may be employed. Steel



pins are driven through the skin into each lateral aspect of the distal end of the bone, femur or tibia as the case may be, and to these the weight and pulley are connected (Fig. 60).

After the fragments have been brought into position they are plated.

#### OPERATION FOR DELAYED UNION AND WANT OF UNION.—

By means of the X-rays it is usually possible to determine the obstacle to union—whether atrophy of the bone, defective callus formation, the interposition of soft tissues between the fragments, or want of apposition of the fragments.

The region of the fracture must be freely exposed, the soft parts separated from the bone, and the periosteum raised together with the superficial bony lamella on its deeper surface (Ollier).

When the bones are atrophied or the callus formation defective, the best procedure is to insert a bone graft, which not only serves to consolidate the union, but may be utilised to fix the fragments. A suitable rod of bone for this purpose can be obtained from the fibula, the crest of the tibia, or one of the ribs of the patient, and it may be shaped so that it can be pushed into the medullary canal of the two fragments. When this is inconvenient, it can be lashed to the surface of the fragments by strands of kangaroo tendon, chromic gut, or silver wire.

If union has been prevented by a piece of muscle, fascia, or other tissue being interposed between the fragments, this must be removed, the ends of the bones freshened, and fixed in apposition. In freshening the ends, it may be possible to shape them so that one will mortise into the other. Failing this, a plate is applied to the surface.

When union has failed owing to displacement of the fragments, the ends must be brought into apposition,

re-freshed, and mortised or plated as is found more efficient.

We have sometimes found it advantageous to place the limb upon the splint in the desired attitude before completing the fixation of the fragments.

## THE OPERATIVE TREATMENT OF INDIVIDUAL FRACTURES

**Fracture of the Neck of the Femur.**—It is to be borne in mind that the patients who usually sustain fracture

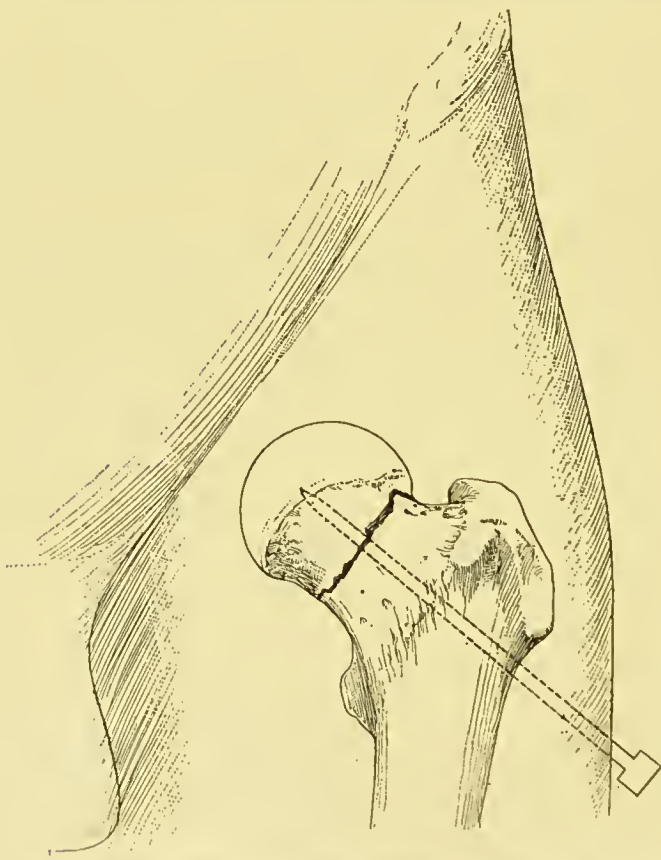


FIG. 61.—Pegging Neck of Femur through Trochanter and Skin.

through the narrow part of the neck of the femur are not as a rule good subjects for operation.

There are two methods of fixation which may be employed. In one, after the fragments have been placed in the best possible position, a stout 8-inch steel pin is pushed through the skin over the trochanter and driven through the neck into the head of the bone (Fig. 61). Its proper location should be verified by the X-rays.

The alternative procedure consists in exposing the site of fracture by dissection from the front. An incision is made downwards and slightly inwards from the anterior superior spine, dividing the skin and fascia and striking the interval between the tensor fasciæ femoris on the outer side and the sartorius on the inner. The capsular ligament is then opened up and the neck of the bone exposed. By manipulating the limb the fragments

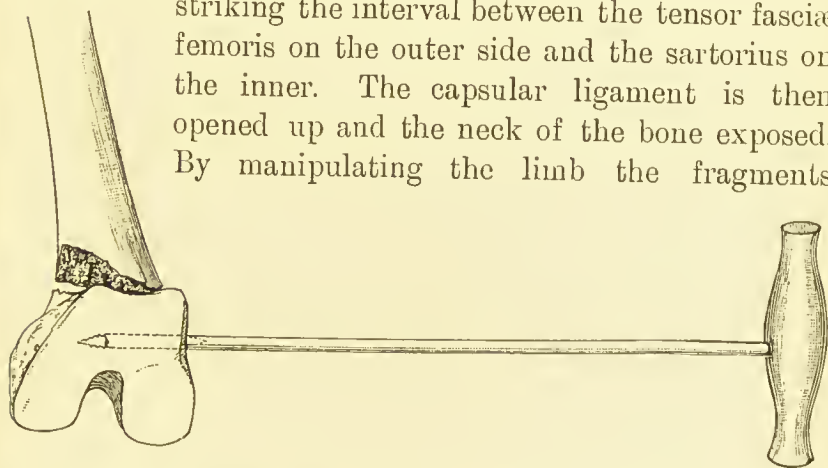


FIG. 62.—The Authors' Screw Lever for manipulating small fragments.

are got into good position and fixed to one another by means of a plate; the torn capsule is then stitched.

**Fracture of the Shaft of the Femur.**—If a choice is possible, the incision should be made in the line of the external inter-muscular septum. In fractures which are not quite recent, and particularly in those situated just above the condyles, and in separation of the lower femoral epiphysis, it may be very difficult to get the fragments into accurate apposition, as the lower fragment cannot be efficiently grasped with any form of forceps. We have found it helpful to drill the bone and insert a screw-

pin with a long handle to obtain the necessary leverage (Fig. 62).

**Transverse Fracture of the Patella.**—The best exposure is obtained by throwing down a horseshoe-shaped flap, the base of which lies a little below the level of the fracture and the lateral margins well beyond the borders of the patella. In some cases a median vertical incision or a horizontal one suffices. After being exposed the fragments are drawn apart, and all blood and serum are washed out of the joint cavity with

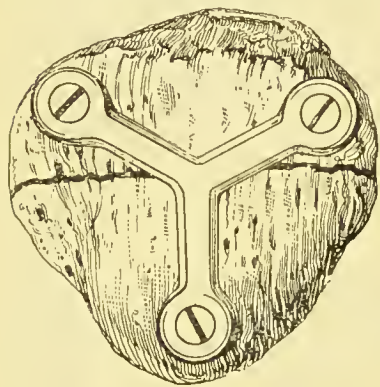


FIG. 63.—Transverse Fracture of Patella, secured by Lane's Plate.

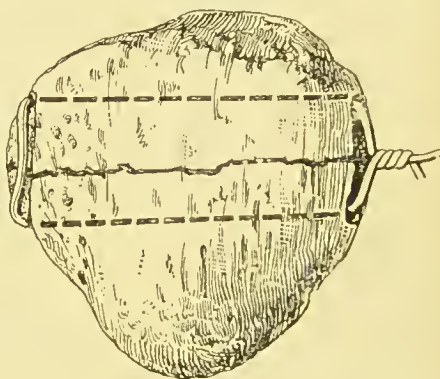


FIG. 64.—Transverse Fracture of Patella, wired.

saline solution or mopped out with moist gauze. The fibrinous blood clot which adheres to the rough surfaces of the fragments is removed with gauze, and any fringe of periosteum that may hang over the edge of the fractured surface is raised so that it does not become interposed when the fragments are approximated. According to the number and arrangement of the fragments, they are retained in position by a steel plate (Fig. 63), or by silver wire sutures passed horizontally (Fig. 64). In drilling the bone, care is taken not to impinge on its articular surface. After the fragments have been approximated the wire is tightened and a double

twist put upon it; the ends are then cut obliquely and the sharp points hammered into the upper fragment. The tendinous expansion of the quadriceps on either side of the knee cap is then stitched with catgut, and the wound closed.

Where an open wound is contra-indicated, the subcutaneous suture of Barker may be employed. A curved-



FIG. 65.—Radiogram of Transverse Fracture of Patella, wired.

handled needle is pushed through the skin and patellar ligament immediately below the lower fragment; it is then guided upwards close to the posterior surface of the patella and made to emerge through the quadriceps and skin immediately above the upper fragment. The needle is threaded with strong silver wire, then withdrawn and the thread removed. Through the original opening, the needle is reintroduced and passed upward close to, but in front of, the fragments and made to



emerge through the upper opening. The needle is threaded again, and withdrawn, so that the wire now surrounds the bone.

The fragments are approximated, the wire tightened and twisted, the excess cut off, and the twisted part buried beneath the skin.

The objections to the subcutaneous operation are that it does not permit of the removal of fascia or periosteum between the fragments nor of suture of the quadriceps expansion.

In *Fractures of long standing*, the bone surfaces must be re-freshed by means of the saw or chisel and all adhesions separated before the fragments are approximated. When the upper fragment has become adherent to the femur, it must be separated. If the fragments are widely separated and there is difficulty in bringing them into apposition, the tubercle of the tibia may be detached and displaced upwards (Lynn Thomas); or the quadriceps may be lengthened by multiple V-incisions, or a flap may be turned down from the rectus femoris and stitched to both fragments of the patella and to the patellar ligament (Rötter).

**Fracture of both bones of the Leg.**—The incision is made on the subcutaneous aspect of the tibia, but the plate should be inserted on the surface of the bone which faces the fibula.

**Fracture of the Clavicle.**—Operative treatment is called for in compound and in comminuted fractures when the fragments have injured or are likely to injure the subclavian vessels or the cords of the brachial plexus. In simple and uncomplicated fractures, it is rarely necessary to operate to correct displacement or to retain the fragments in position. The seat of fracture is exposed, loose fragments removed, and the ends of the bones sutured or plated.

**Fracture of the Upper End of the Humerus.**—Access to

the fragments is obtained by an incision carried between the pectoralis major and the deltoid, and the latter muscle is strongly retracted outwards, care being taken not to injure the cephalic vein. If there is difficulty in getting the head of the bone or the tuberosity into position, it should be drilled and have a screw-pin with a long handle inserted into it to afford leverage (Fig. 62). In the after-treatment, the arm is to be maintained in the attitude of right-angled abduction for ten days or a fortnight, and then from day to day the angle is reduced.

**Fracture of the Neck of the Humerus complicated with Dislocation of the Shoulder.**—When it is impossible to reduce the dislocation by external manipulation, the upper fragment of the humerus is exposed by an incision over its outer aspect, and with the aid of M'Burney's hook, Lane's lever, or a long steel screw (Fig. 62) sufficient purchase can usually be obtained to lever the head into the glenoid cavity. Before the wound is closed, the fracture is adjusted and the fragments plated or wired in position.

**Fracture of the Shaft of the Humerus with Implication of the Musculo-spiral Nerve.**—An incision is made on the outer aspect of the arm, and the nerve is first exposed and freed from pressure, or if it has been torn, the ends are isolated and held aside. The ends of the bone are then mortised into one another or fixed by means of a medullary splint, or by silver wire or a metal plate as may be found most appropriate. The ends of the nerve are then sutured and buried in the substance of the triceps muscle, or insulated by tubular suture (p. 84). Special care must be taken that the hand is fixed in the dorsi-flexed position during the after-treatment.

**Fracture of the Lower End of the Humerus.**—According to the site of the injury the incision is made in the middle line posteriorly, or in the line of the inter-muscular septum on one or on both sides. When the fragments

have been got into position, there may be no tendency to redisplacement; should there be such tendency, a small steel plate or a suture of wire or catgut is inserted.

**Fracture of the Olecranon Process** is treated on the same lines as fracture of the patella.

**Fracture of the Bones of the Forearm** may be treated in the same way as fracture of the bones of the leg.

## OSTEOTOMY

This operation, which consists in making a clean cut into or through a bone, is best performed by means of a sharp instrument the cutting edge of which is equally bevelled on the two sides. The osteotome devised by Macewen is that most generally employed. It is made in three sizes and has a graduated scale in half-inches marked on its side. The part to be operated upon rests upon a firm sand-bag, and the osteotome, is driven into the bone by means of a steel mallet.

In some situations a saw is more convenient. If the bone to be divided is comparatively superficial and can be cleared all round, the Gigli wire saw is to be preferred. For more deeply placed parts, for example, the neck of the femur, Adam's osteotomy saw, as modified by Robert Jones by the addition of a hook-like expansion at the free extremity of the blade, is more suitable.

In using the Adam's saw, a short incision is made down to the bone, the soft parts are cleared from the surface with a raspatory until there is room to admit the blade of the saw, which is carried through the bone by short rapid strokes. The use of Gigli's saw necessitates a longer incision and a freer reflection of the periosteum to admit of the passage of the flexible introducer by which the saw is carried round the bone. One of the disadvantages of the Gigli saw is its liability to break while in use. This can to a large

extent be obviated by keeping the hands as wide apart as possible, and by cooling the saw by irrigating with cold saline solution. When not in use, the wire saw should be kept straight and not coiled up in a roll.

**OSTEOTOMY FOR KNOCK-KNEE AND BOW-KNEE.**—It is convenient to take these deformities to illustrate the two methods of performing osteotomy—the *linear*, which is almost a subcutaneous operation, and the *cuneiform*, carried out through an open wound.

Macewen's classical operation for knock-knee may be taken as the best example of the **linear** type. The limb is laid on its outer side upon a sand-bag; at a point where two lines meet—one a finger's breadth above the patella, the other a finger's breadth in front of the tendon of the adductor magnus—the knife is introduced in the long axis of the limb and made to cut directly down upon the bone through the substance of the vastus internus. The incision is just long enough to admit the largest osteotome, which is then passed alongside of the knife down to the bone and turned so that its edge is at right angles to the long axis of the femur (Fig. 66). The osteotome is grasped with the left hand, the ulnar border of which rests on the limb, and driven through the bone by successive

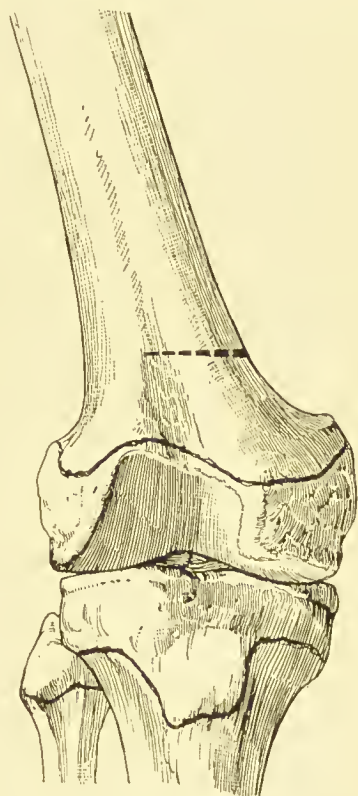


FIG. 66.—Macewen's Operation for Knock-knee.

Site of division of bone indicated by dotted line; the epiphyses indicated by a continuous dark line.



blows of the hammer, the osteotome being slightly withdrawn or rocked laterally between the strokes so as to prevent it becoming jammed. After the cortex has been divided through fully half the circumference of the bone, a finer osteotome is passed along the face of the first and substituted for it, and the division continued until at least three-quarters of the thickness of the bone is cut through, after which the osteotome is withdrawn. The wound is then covered with gauze, and one hand grasps the femur at the site of operation and the other the leg about its middle and forcibly abducts the latter until the femur breaks across with an audible snap, after which, with a little manipulation, the deformity is easily rectified. There is some oozing of blood from the bone-marrow, but it soon stops. The wound is sutured, and the limb put up in a splint for ten days with the toes well inverted, or weight extension is applied.

The condition is now for practical purposes to be looked upon as an aseptic compound fracture and is to be treated as such.

The same operation may be performed from the outer side with equally satisfactory results (John Duncan).

Robert Jones, in performing this operation, divides the femur through three-fourths of its thickness with his modified Adam's saw, and he recommends that the remaining fourth should not be broken across until after the wound has healed.

**Cuneiform Osteotomy for Knock-knee by Open Operation.**—The advantage of the open operation is that the operator sees exactly what he is doing, and the rectification of the deformity is more accurate. The operation we practise is modified from that of Chiene and of Ogston.

With the limb flexed at the knee and placed upon its outer side on a sand pillow, a longitudinal incision



is made on the inner aspect, about two fingers' breadth in front of the adductor magnus tendon. The skin, superficial and deep fasciæ having been divided, the inner edge of the vastus internus is exposed and drawn forcibly outwards and upwards, or, the fibres of the muscle may be divided in the line of the wound: in doing this one or more branches of the anastomica will require to be secured. The soft parts are widely retracted so as to give an ample view of the inner aspect of the bone. At the lowest part of the wound the superior internal articular artery and vein cross the bone, and should be secured by a double ligature before being divided. By means of the osteotome a wedge of bone is removed with its base on the inner aspect and its apex directed towards the intercondyloid notch but not encroaching on the epiphysial cartilage (Fig. 67). When the wedge is removed the correction of the deformity is immediate and decidedly more accurate than in the linear operation.

In extreme cases of knock-knee in which there is a tendency to outward dislocation of the patella, this must be counteracted by over-correction of the deformity in the direction of genu varum.

In the rare cases of knock-knee in which the deformity is chiefly due to obliquity of the tibia, it may be necessary to remove a wedge from the tibia with its base on the inner aspect; this is done through

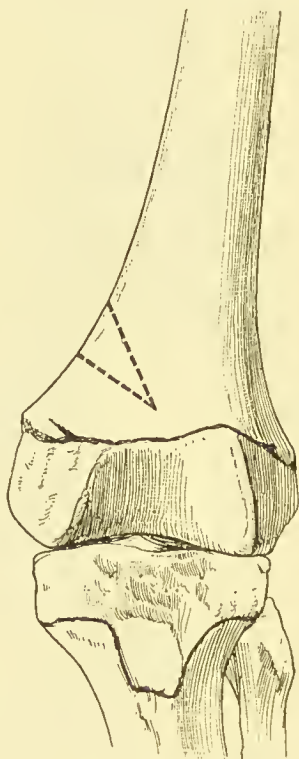


FIG. 67.—Cuneiform Osteotomy for Knock-knee. The epiphyses are indicated by continuous dark lines.

a horizontal or semilunar incision on the inner aspect of the limb.

**Operation for Genu Varum.**—For this deformity it is usually necessary to perform linear osteotomy or to remove a wedge from the inner aspect of the tibia below the epiphysial line, in addition to linear osteotomy of the femur above the condyles. The tibia is exposed by a vertical or semilunar incision.

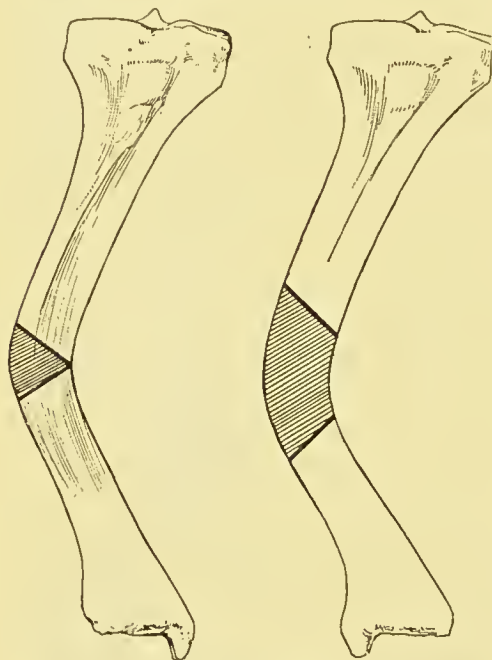


FIG. 68.—Wedge-shaped Resection of Tibia for Rickety Curvature.

**Osteotomy of the Tibia.**—In bow-leg and other deformities of the leg resulting from rickets, it is as a rule only necessary in young subjects to operate on the tibia, as the fibula may be bent or fractured by manual force. After rendering the limb bloodless, a longitudinal or semilunar incision is made over the most prominent part of the curve of the tibia, the peri-

osteum divided and reflected, and linear or euneiform osteotomy performed. We have found it advantageous to remove a segment of the bone by means of the Gigli saw (Fig. 68). In the adult it may also be necessary to divide the fibula with the osteotome.

**OSTEOTOMY OF THE UPPER END OF THE FEMUR.**—This operation is most frequently called for to correct the deformity resulting from neglected hip joint disease, in which the limb is fixed in the

position of flexion with adduction. It may also be required in cases of coxa vara, and in badly united fractures of the neck and trochanters of the femur.

**Division of the Narrow Part of the Neck of the Femur** (*Adam's Operation*).—A long narrow-bladed knife is introduced between the tensor fasciæ femoris and the sartorius, at a point one finger's breadth above the great trochanter, and, with its blade parallel with Poupart's ligament, is pushed on until it encounters the neck of the femur. An Adam's saw, as modified by Jones, is passed alongside the knife, and the teeth of the saw are brought into contact with the anterior aspect of the neck of the bone; the knife is then withdrawn and the neck of the bone sawn through. When there is adduction deformity, the tendons of the adductor longus, pectineus, and gracilis may require to be divided subcutaneously; when there is marked flexion, the muscles and fasciæ in front of the joint may require to be divided. The limb is put up in the abducted position (Fig. 288, vol. i.).

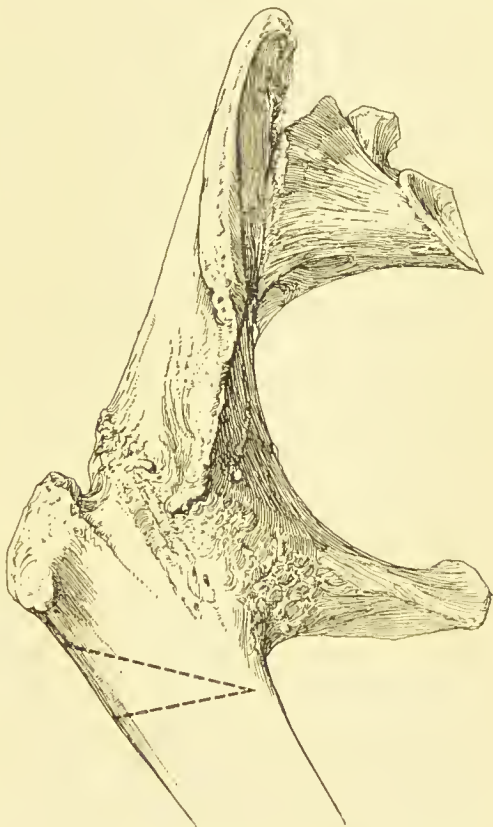


FIG. 69.—Cuneiform Osteotomy below the Trochanters.

**Osteotomy below the Trochanters** (*Gant's Operation*).—

An oblique incision is made over the outer aspect of the limb, dividing the skin and the tendon of the gluteus maximus at the level of the base of the great trochanter. The transverse terminal branch of the external circumflex artery runs parallel to the incision. The bone is then divided obliquely downwards, forwards, and inwards so as to prevent the lower fragment being displaced inwards or forwards when the limb is abducted (Kocher). The limb is put up in the abducted position. As the level of the lesser trochanter is about two inches below the top of the great one, the osteotome should be applied about half an inch or more below the latter (Burghard).

Instead of a linear osteotomy, a wedge may be removed with its base directed outwards (Fig. 69).

**Trans-trochanteric Osteotomy.**—This is performed most frequently for the adduction deformity resulting from hip disease or coxa vara. The osteotomy may be linear (Fig. 70) or euneiform (Fig. 71). An oblique incision with its centre at the upper margin of the great trochanter is made on the outer aspect of the limb, and the tendinous expansion of the gluteus maximus is divided and held aside. If a linear osteotomy is sufficient to correct the deformity, the bone is divided obliquely from above, downwards, forwards and inwards from near the tip of the great trochanter to the lesser trochanter. If a euneiform resection is necessary, irrespective of the muscular attachments, a wedge is removed with a large osteotome or chisel, the base of the wedge being at the junction of the great trochanter with the neck, and the apex in the region of the lesser trochanter (Fig. 71). The size and shape of the wedge depend on the nature of the deformity, and this should be ascertained beforehand by means of stereoscopic radiograms. To enable the limb to be put up in the desired attitude of abduction, it may be necessary to divide the contracted soft parts subcutaneously.

**The Lengthening of Bones in Shortened Limbs.**—In a shortened lower extremity the femur, or the tibia and fibula, as the case may be, may be split longitudinally as in the lengthening of a tendon (Fig. 72), after which the soft parts are stretched by means of powerful traction, and the fragments of bone are pulled out from one another, and fixed by plates in their new position (Anschütz).

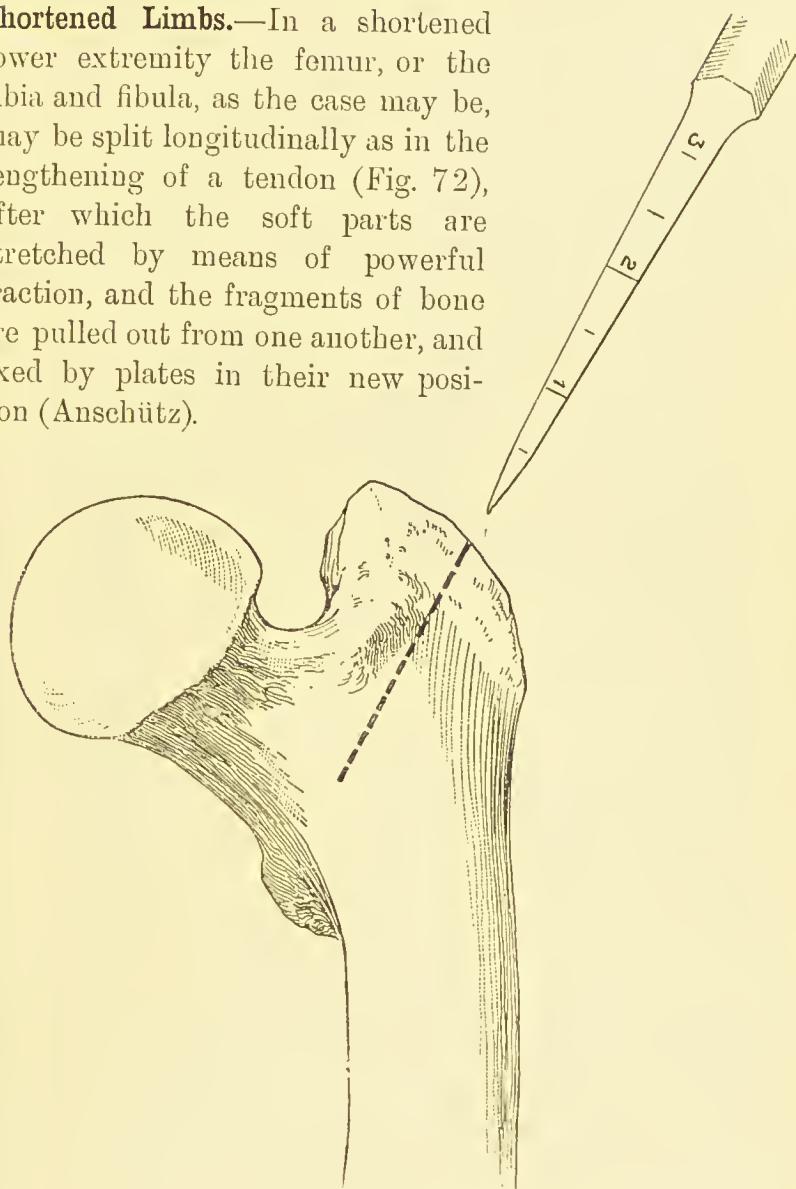


FIG. 70.—Linear Trans-trochanteric Osteotomy.

**Sub-periosteal Resection of a Long Bone.**—For the diffuse form of tuberculous osteomyelitis met with in children, opening the marrow and attempting to eradicate



the disease with a gouge and sharp spoon is not sufficiently thorough, and the most satisfactory treatment is subperiosteal resection of the shaft (H. J. Stilcs). The amount of bone to be removed can be fairly accurately decided upon beforehand by means of skiagrams. The incision is planned so as to expose fully the affected segment of bone and at the same time to do the least possible injury to the soft parts. The periosteum is then

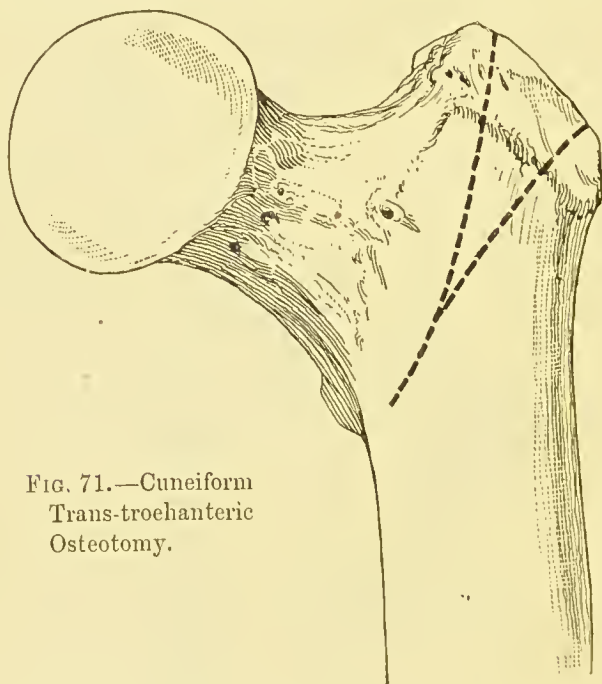


FIG. 71.—Cuneiform  
Trans-trochanteric  
Osteotomy.

incised and separated all round, and a Gigli's saw is passed round the bone, which is sawn across beyond the disease. By means of a strong hook inserted into the medullary canal, the divided end of the segment to be removed is forcibly dragged upon, the periosteum is further separated, and the Gigli's saw again applied beyond the other extremity of the diseased portion. If necessary, the diaphysis may be removed right up to the epiphysial cartilage. When the oozing has ceased,

the periosteal tube is completely closed by an interrupted catgut suture, special care being taken to cover the sawn ends of the bone. Any fascia which has been divided is also stitched, and the skin wound closed with interrupted sutures. The bone is usually perfectly re-formed in from three to six months.

We have also performed this operation for relapsing forms of staphylococcal osteomyelitis and for syphilitic lesions which have refused to yield to less severe measures.

### **Resection of a Long Bone together with the Periosteum.**

—This is chiefly called for in cases of myeloma at the end of the diaphysis of a long bone in young subjects. It may be employed also in early cases of sarcoma, which were formerly subjected to amputation. The amount of bone to be removed can be estimated beforehand with the aid of skiagrams.

As the periosteum is removed, no new bone will be formed, and a substitute must therefore be inserted. In the case of one of the smaller bones, such as the

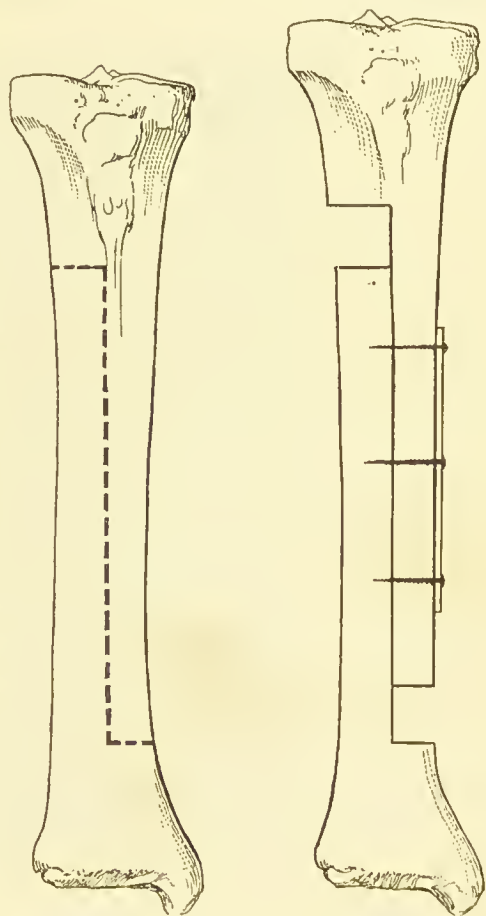


FIG. 72.—Lengthening of Tibia.

radius, the ulna, or a metacarpal bone, a substitute is easily provided from the patient's fibula, rib, or metatarsal, or from the crest of the tibia. The bone selected is cut down upon, cleared of soft parts but retaining its periosteum, and a portion of it, somewhat longer than the



FIG. 73.—Radiogram of portion of Fibula implanted into Humerus after Resection for Sarcoma.

gap it is intended to fill, is removed with the Gigli saw. The simplest method of implanting the graft is to shape it at either end with a chisel and drive it into the medullary canal (Fig. 73).

When the sarcoma has erupted through the shell of the bone, the adjacent soft parts must be sacrificed, and

this may entail damage to important vessels and nerves. In resecting the humerus for sarcoma, for example, a portion of the musculo-spiral nerve may have to be sacrificed, in which case the upper and lower ends of the nerve may be inserted by lateral implantation into the median or musculo-cutaneous trunk.

For gaps in larger bones, such as the humerus, femur, or tibia, there is greater difficulty in providing a substitute. Re-

course may be had to bisecting the tibia of the patient in the greater part of its length (Fig. 74), and using one-half as a graft, or a graft may be obtained from a recently amputated limb, or even from the cadaver. Küttner removed the upper third, including the head of the femur, in an adult for sarcoma,

and made good the defect by inserting the corresponding portion of the thigh bone from a man who had died of cerebral tumour. Four months later, the healing was complete, and the transplanted portion was firmly united to the shaft.

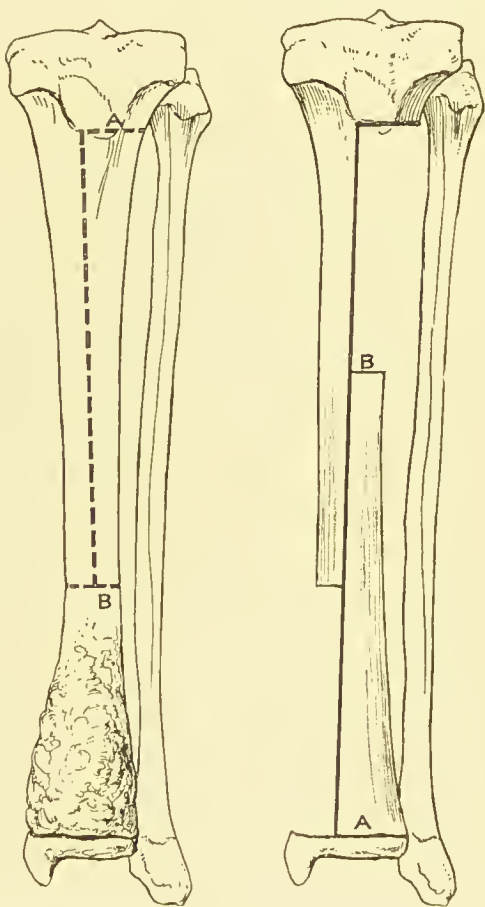


FIG. 74.—Resection of Sarcoma of Lower End of Tibia.

## CHAPTER X

### OPERATIONS ON TENDONS

TENOTOMY: *Subcutaneous*; *Open*. LENGTHENING OF TENDONS.  
SHORTENING OF TENDONS. TRANSPLANTATION OF TENDONS

**Tenotomy.**—The operation of *subcutaneous tenotomy*, introduced by Stromeyer, consists in dividing a tendon by means of a short narrow-bladed knife with a rounded stem between the blade and the handle. The tenotome is made to puncture the skin, and the blade is passed either between the skin and the tendon, or underneath the tendon, according to circumstances. The tendon is then put upon the stretch and cut across, the knife withdrawn, and the puncture covered with a pad of gauze.

This procedure has been almost entirely replaced by *open tenotomy*, the tendon being exposed through an incision which is usually made parallel with the tendon, and divided under the guidance of the eye. By the open operation the division of the tendon is more accurately performed, and other structures, such as fasciæ and ligaments, can be dealt with through the same wound. Further, it is possible to lengthen the tendon, instead of merely cutting it across, and in many conditions this procedure is preferable.

**Lengthening of a Tendon by Open Operation.**—This operation is performed in preference to simple tenotomy in many cases of club foot, particularly when the tendo Achillis is contracted, and in contractures of limbs due



to nerve lesions.- To lengthen the tendo Achillis, for example, an incision is made to one side of the tendon, above the level where it is immediately subcutaneous. The tendon is defined and is divided in a Z-shaped

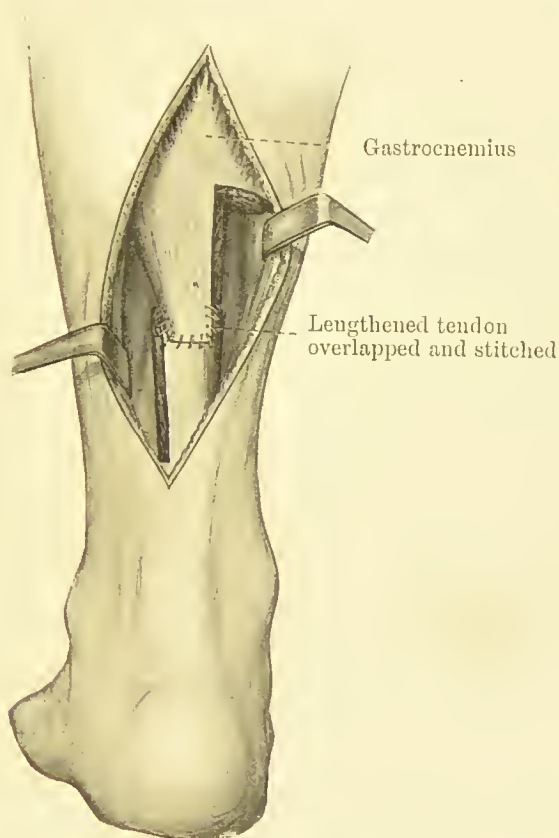


FIG. 75.—Lengthening of Tendo Achillis.

manner, the distance between the two horizontal limbs of the Z corresponding to the amount of lengthening required. The position of the foot is then corrected, and the tendon sutured as is shown in Fig. 75. If the horizontal cuts in the tendon are bevelled from above downwards, broader surfaces are obtained for suturing. We have found this method more satisfactory than a

single oblique division of the tendon and sliding of one segment on the other, or than the various plastic operations by flaps.

**Shortening of Tendons.**—The simplest means of shortening a tendon is to resect the redundant portion by two obliquely parallel incisions, and suture the ends together with fine chromicised catgut. Another method is to detach the tendon at its insertion, remove a portion, and reinsert it.

**Transplantation of Tendons.**—This operation, originally devised by Nicoladoni, is chiefly called for in cases of anterior poliomyelitis, in which individual muscles or groups of muscles are paralysed. The operation consists in dividing the tendon of an active muscle as close to its insertion as possible, and either grafting it laterally into a slit in the tendon of the paralysed muscle, or dividing the latter tendon and joining them end to end. Lange of Munich and Jones of Liverpool, who have done much to develop the technique of these operations, advise that the reinforcing tendon should be attached to the periosteum by silk sutures rather than to the paralysed tendon; for example, if the quadriceps femoris is paralysed, one or more of the flexors should be inserted into the periosteum and fascia covering the lateral edges of the patella. If the reinforcing tendon is at a distance from the receiving tendon, a second incision is necessary, and the tendon is carried from one opening to the other through a tunnel bored with a blunt instrument. If the tendon is too short, it is prolonged by means of silk threads; and the reinforcing tendon should run as nearly as possible in a straight line, as a good deal of power is lost if it is carried round an angle. Particular care should be taken that the grafted tendon is united with the right degree of tension, so that the desired effect may be produced when the muscle contracts. Active movements are begun in the course of a week or a fortnight. (See also vol. ii. p. 827.)

## CHAPTER XI

### OPERATIONS ON JOINTS

GENERAL PRINCIPLES. DEFINITION OF TERMS: Arthrotomy—Excision—Arthrolysis or Arthroplasty—Transplantation—Arthrodesis—Tapping and Irrigation of Joints. OPERATIONS ON BONES AND JOINTS OF LOWER EXTREMITY: For Hammer-toe by Resection of Head of First Phalanx—For Hallux Valgus by Resection of Head of First Metatarsal—Resection of Tarsus by Dorso-lateral Incisions—Wedge Resection of Tarsus for Club-foot—Excision of Astragalus—Excision of Os Calcis—Arthrotomy, Arthrodesis, and Excision of Ankle Joint—Mikulicz' Osteo-plastic Resection of Foot—Arthrotomy and Excision of Knee by Kocher's Incision—Removal of Articular Surfaces of Femur and Tibia—Arthrotomy for Torn Internal Semilunar Cartilage—For Tuberculous Disease of the Patella. OPERATIONS ON THE HIP JOINT: Arthrotomy by Anterior Incision—Excision for Tuberculous Disease—For Anklyosis—For Disease of the Ilium and Sacro-iliac Joint. OPERATIONS ON BONES AND JOINTS OF THE UPPER EXTREMITY: On Fingers and Hand—Excision of Wrist—Arthrotomy and Excision of Elbow—Arthrotomy and Excision of Shoulder—Resection and Total Excision of Scapula—For Recurrent Dislocation of Shoulder.

THE details of the different operations performed upon joints vary with the object of the operation and with the particular joint implicated, and are most conveniently considered regionally. There are, however, certain general principles applicable to all such operations, which, to avoid repetition, may be mentioned here. The surgery of the joints was first put upon a sound basis by

the work of Langenbeck, Ollier, and Syme, and for its more modern developments we are most indebted to Koehler.

**General Principles of Operations on Joints.**—Opinion is a good deal divided as regards the advantages of employing a *tourniquet* in operations upon joints. The convenience of operating in a bloodless field is great, but may be counterbalanced by the increased risk of reactionary hæmorrhage, which interferes with the healing of the wound. The prolonged application of a constricting bandage, moreover, is not infrequently followed by paralysis of one or more of the nerve trunks pressed upon. As a working rule, it may be stated that if the operation is likely to be a prolonged one, the tourniquet should be dispensed with; while in short operations it may be employed, and it should not be removed until the dressings and bandage have been applied and the limb elevated.

The *incision* made to expose a joint should be as simple as possible consistent with affording free access (Langenbeck); and should be placed in the intervals between muscles, tendons and ligaments in order that the least possible damage is inflicted on soft parts, and particularly on the nerves supplying the muscles that act upon the joint (Koehler). The primary incision should always be planned so that it can be extended if it is found necessary to perform a more extensive operation than was at first contemplated. We have found the "hooked" or J-shaped incisions employed by Koehler the most generally useful.

In dissecting down upon the capsule, special care should be taken not to damage the small branches of nerves passing to muscles, and the attachments of the muscles and tendons acting upon the joint should be disturbed as little as possible.

The capsule is divided in the long axis of the limb

and is detached in continuity with the periosteum of the adjacent bones. For this purpose a sharp-edged instrument, such as an osteotome or chisel, is employed so as to raise not only the deeper osteoblastic layer of the periosteum but also the superficial lamellæ of the cortex of the bone. The old-fashioned periosteal elevator, which only raises the fibrous layer, should be discarded.

It is most important to preserve the attachments of ligaments and tendons to bone, and the plan introduced by König and Teilung of chiselling off the bony processes to which these structures are attached, and subsequently securing them in place again by peg or suture, has much to recommend it.

In performing arthrotomy, for example for the removal of a loose body or detached semilunar cartilage, it is of the utmost importance not to handle the joint surfaces unduly, and to carry out all manipulations inside the joint with instruments rather than with the fingers. All hæmorrhage from the synovial membrane and ligaments should be arrested, preferably by forcible pressure or torsion, before the capsule is sutured.

In operations necessitating the removal of articular cartilage and bone, the amount to be removed is determined by the extent and disposition of the disease, and by the subsequent function of the joint. When, for example, it is desired that ankylosis should occur between the exposed bony surfaces, as is nearly always the case at the knee, the ends of the bones should be shaped so that they fit into one another in such a way as to favour sound osseous union, and they may be fixed by nails or pegs. When, on the other hand, a movable joint is aimed at, as at the elbow, the ends should be moulded into the shape of the normal joint, and to prevent them fusing and becoming ankylosed, a layer of fascia or other soft tissue, comprising if possible



a quantity of fatty connective tissue, should be interposed between them and stitched in position.

The dressing should be an abundant one for purposes of support and compression, and should preferably contain an antiseptic so that it need not be changed for ten days or a fortnight. The limb is secured on a suitable splint or other appliance.

**DEFINITION OF TERMS.**—The term **Arthrotomy**, or incision of a joint, is employed when a joint is opened for purposes of exploration or of drainage, for the removal of a loose body, or to deal with a displaced or torn intra-articular cartilage.

The incision is planned so as to entail the least possible damage to the soft parts, particularly the nerves supplying the muscles. It will necessarily penetrate through skin, aponeurosis, capsule, and synovial membrane, and these should be stitched separately in closing the wound. If further oozing into the joint is expected, a drainage tube should be inserted, as thereby much pain from tension will be prevented.

**Excision** of a joint implies the removal of all the articular structures — cartilage, bone, and synovial membrane — because they are either so diseased or so badly injured that recovery with a functionally useful joint cannot be expected. French and German authors use the term “resection” in a similar sense. The term *arthrectomy* has been employed to indicate the removal of diseased synovial membrane and articular cartilage without any gross interference with the bones, but as its employment in this sense is misleading and is liable to cause confusion, it should be given up.

We have long agreed with König and Koehler in teaching that the day of “typical excisions” is past. When we proceed to excise a joint we aim at removing the articular structures that are diseased, in such a way as

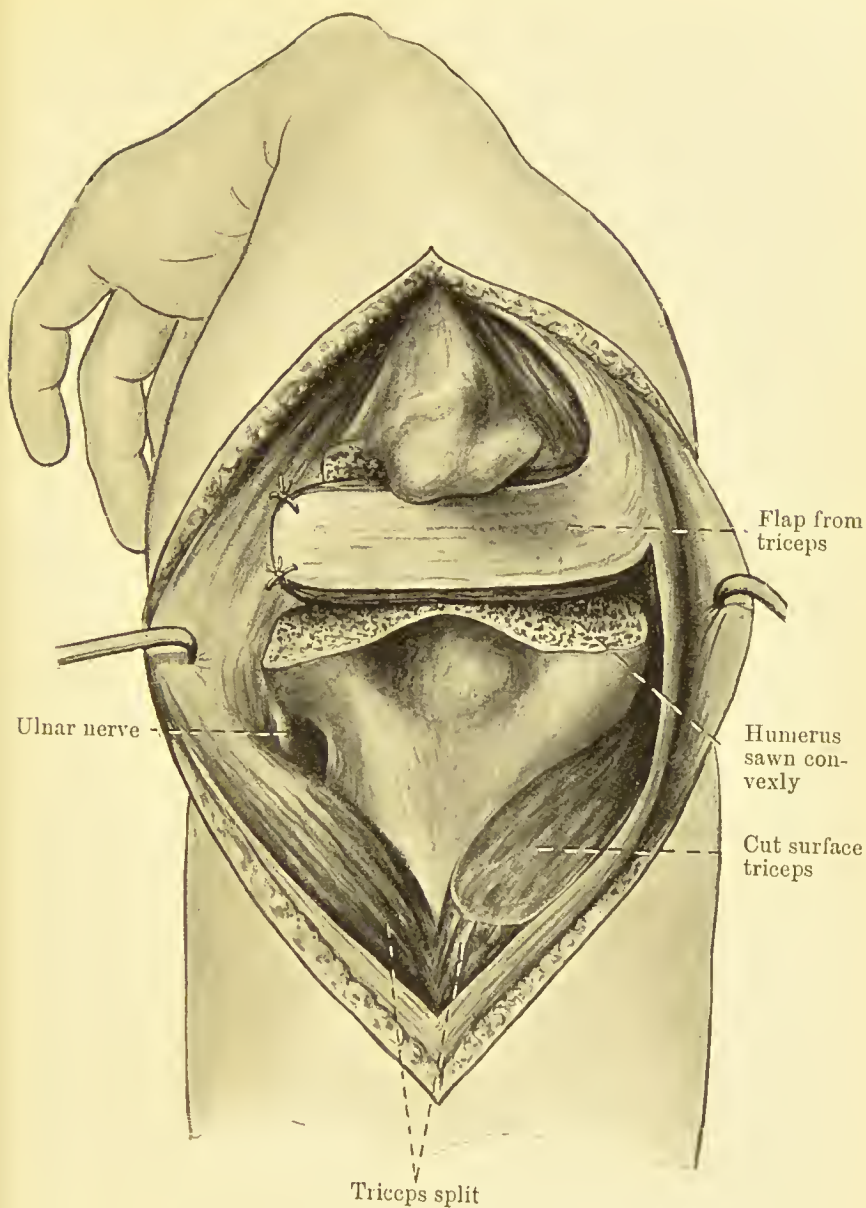


FIG. 76.—Arthrolysis or Arthroplasty at elbow (after Schmieden).

will best contribute to the restoration of the functions of the joint.

**Arthrolysis or Arthroplasty.**—These names are given

to the operation which is designed to restore mobility to an ankylosed joint. The method of Murphy of Chicago is that most often followed. He imitates by art what occurs in nature when non-union of a fracture is due to the interposition of soft structures between the fragments. The bones entering into the joint are freely exposed, and the union between them divided; the articular surfaces are shaped in the way that will best facilitate their movement on one another, and are made as smooth as possible. Any contracted structures that will interfere with the desired movements of the joint are divided or lengthened. In the upper extremity there need be no hesitation in sacrificing a considerable amount of bone. A thick layer of the neighbouring soft structures, preferably consisting of a layer of fascia with plenty of fat, is dissected up in the form of a flap, inserted between the ends of the bones, and secured in position by sutures. The soft parts are then brought together and the wound closed. The further details of the operation vary in the different joints.

**Transplantation of Joints.**—Attempts have been made with an increasing measure of success to replace joint structures which have been destroyed or have had to be removed, by the corresponding joint-structures taken from the patient, from a recently amputated limb, or from the cadaver. Lexer of Königsberg and Tuffier of Paris have recorded remarkable successes; the former inserted the knee joint from a recently amputated limb into a girl aged 20, whose knee joint had been resected for disease, and two and a half years later the healing was quite sound and the functions satisfactory.

**Arthrodesis.**—The aim of this operation is to bring about ankylosis, and it is chiefly of service in rendering more useful the flail-joint of a paralysed limb. For example, by stiffening a flail knee-joint in the extended position, the lower limb may be rendered capable of

supporting the body weight; while by ankylosing a flail elbow in the flexed position, the range of usefulness of the hand may be greatly increased.

The most certain way of producing ankylosis is by removing the articular cartilage from the ends of the bones so that these will grow together like the fragments in a fracture. The incision and dissection required to expose the articular ends of the bones vary in different joints; it is usual to remove with the chisel a layer of bone along with the articular cartilage. Sometimes the ends of the bones are fixed to one another by nails or plates, and external support must be provided by means of a splint or other appliance until the ankylosis is complete. Attempts to bring about ankylosis solely by driving pins through the bones from without have not been successful.

**Tapping and Irrigation of a Joint.**—A trocar and cannula are pushed in through the overlying integument, capsule, and synovial membrane. If there is an excess of fluid, it will escape through the cannula on withdrawing the trocar; the irrigating fluid can then be made to run in by gravitation or by using a syringe.

## OPERATIONS ON THE BONES AND JOINTS OF THE LOWER EXTREMITY

**Operation for Hammer-toe by Resection of the Head of the First Phalanx** (Fig. 77).—A longitudinal incision is made down to the bone on either dorsi-lateral aspect of the toe; the extensor tendon is held aside and the head of the first phalanx, after being cleared, is protruded at the wound, and removed with bone pliers. If there is a corn or an inflamed bursa on the dorsum, this is also removed by an elliptical incision carried round it.

**Operation for Hallux Valgus by Resection of the Head of the First Metatarsal.**—In pronounced cases of hallux



valgus the operation devised by C. H. Mayo yields the best results (Figs. 78 and 79). The skin is first dissected from off the bunion in the form of a flap with its base below, and then the bursa is outlined by a horseshoe-shaped incision, the concavity of which is directed backwards, and folded forwards. The head of the metatarsal bone is now removed with the osteotome,

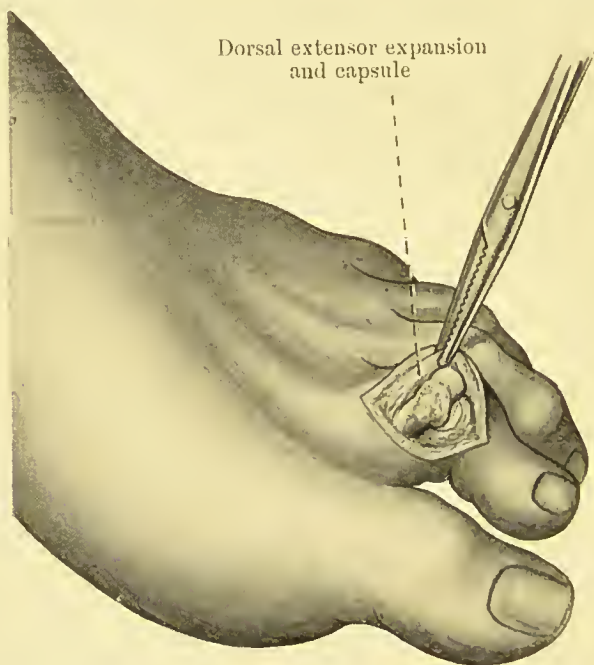
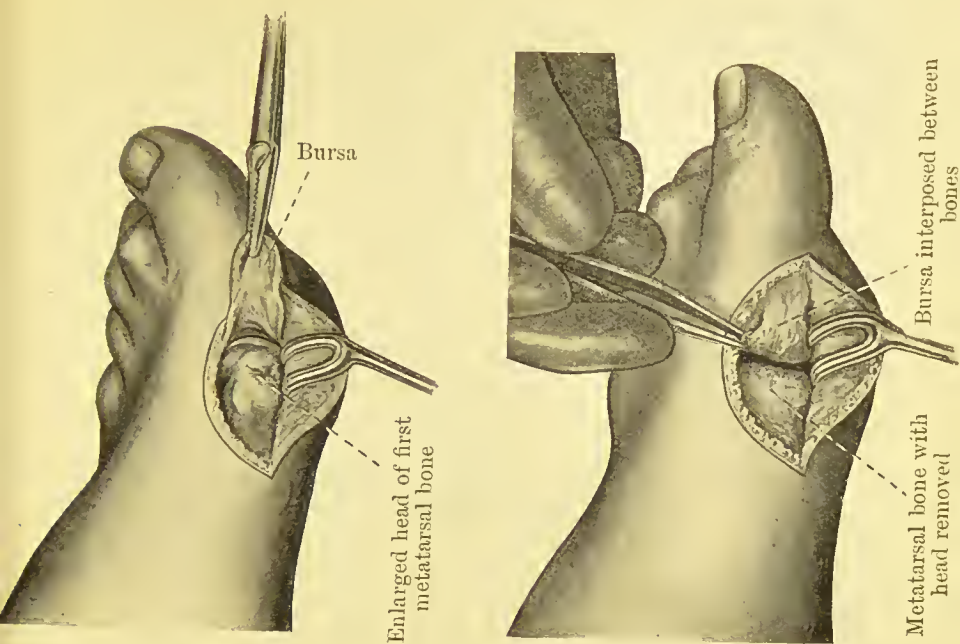


FIG. 77.—Correction of Hammer-toe by Resection of the Head of the First Phalanx.

and the end of the shaft rounded off with bone pliers. The bursal flap is then turned in so that it is interposed between the divided metatarsal and the base of the first phalanx, and is held in position by two catgut sutures passed through and knotted over the skin at the web. The skin flap is replaced and sutured in position.

In milder cases it is sufficient to excise the bursa and chisel off the projecting portion of the head of the metatarsal bone.





(a) 1st stage.

(b) 2nd stage.

FIG. 78.—Mayo's Operation for Hallux Valgus.



FIG. 79.—Skiagram showing result of Operation for Double Hallux Valgus.

**Resection of the Tarsus by Lateral Incisions.**—This operation is usually performed for tuberculous disease, the extent of which is determined beforehand with the aid of skiagrams. It is generally necessary to

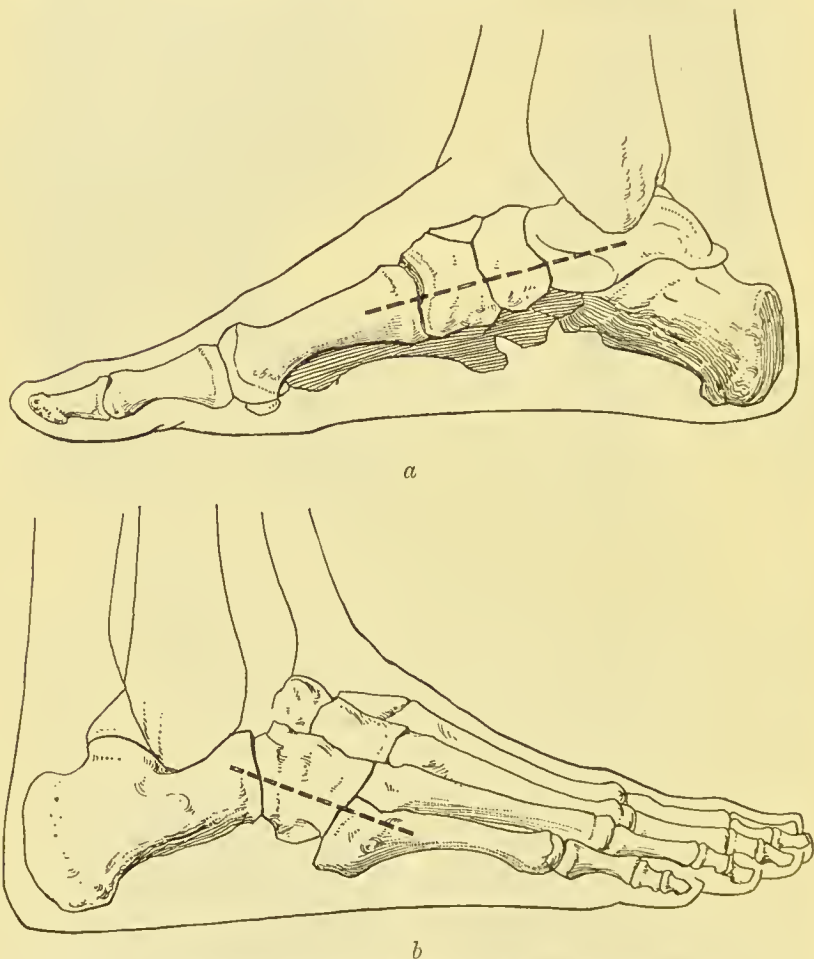


FIG. 80.—Resection of Tarsus by Lateral Incisions.

resect the bases of the metatarsal bones and the anterior row of the tarsus (*tarso-metatarsal resection*), but if the disease is more extensive, the posterior section may require to be made through the astragalus and os calcis (*complete anterior tarscetomy*).

The internal incision extends from the posterior third of the first metatarsal bone backwards as far as the head of the astragalus, the posterior part of the incision dividing the skin only, so as to avoid opening that part of the ankle joint which projects forwards on to the neck of the astragalus (Kocher) (Fig. 80, *a*). The attachment of the tibialis anticus to the first metatarsal and internal cuneiform is divided, and the cuneiform and scaphoid bones are exposed and cleared on their under aspect.

The external incision extends from the posterior third of the fifth metatarsal to a little in front of the external malleolus (Fig. 80, *b*); the tendons of the peroneus tertius and brevis are detached from the base of the fifth metatarsal, and that of the longus is drawn from its groove in the cuboid.

Advantage is taken of both incisions to clear the bones further, first on the dorsum and then on the sole, and by means of the key-hole saw they are divided in front and behind well beyond the limits of the disease. The foot is shortened but is quite useful, both for support and movement.

When there is extensive disease in the soft parts as well as in the bones, it is a useful plan to join the anterior ends of the lateral incisions by a transverse one across the dorsum, thus marking out a flap which, on being reflexed, gives good access.

**Wedge-resection of Tarsus for Club-foot.**—We have found Kocher's method of performing this operation the most satisfactory. The incision commences over the dorsal aspect of the astragalo-scaphoid joint and passes obliquely downwards and backwards towards the outer border of the heel. The musculo-cutaneous nerve is seen lying upon the fascia at the upper angle of the wound, and the short saphenous nerve appears at its lower angle: these nerves are drawn aside, and one or two veins are seized and twisted. After division of the

fascia, the tendon of the peroneus tertius appears at the upper end of the wound, and at its lower part are the long and short peroneal tendons in contact with the outer surface of the os calcis. After their sheaths have been slit up, the tendons are drawn aside with blunt hooks. The capsule is divided over the head of the astragalus, and the joint opened. The attachment of the capsule is then separated from the neck of the astragalus as far as the groove on its under surface. After the upper border of the extensor brevis digitorum has been exposed and drawn downwards, the calcaneo-cuboid joint is opened. The neck of the astragalus and the greater process of the os calcis are now divided with a chisel, and drawn well out of the wound with a sharp double hook, so that they may be completely freed from their ligamentous connections and removed. In order that the foot may be dorsi-flexed to less than a right angle by firmly pressing together the osseous surfaces, it is necessary in aggravated cases of club-foot to shell out the whole of the scaphoid and to chisel off a portion of the cuboid. The introduction of a drainage tube is not necessary, as there is no cavity remaining, and no reactionary hæmorrhage is to be anticipated. The wound is closed by a continuous suture. The foot is kept dorsi-flexed and the knee bent by means of a plaster of Paris bandage, which extends above the knee. To ensure a satisfactory result it is generally necessary to elongate the tendo Achillis.

The important points to be attended to are to obtain primary healing, and to see that the deformed attitude is over corrected.

**Excision of the Astragalus (Os Talus).**—When removal of the astragalus is called for in injuries at the ankle joint, the incision is made over the most projecting part of the bone. In club-foot also the bone projects on the dorso-external aspect and is cut down upon over its most prominent part.

In tuberculous disease (the condition having been demonstrated by the X-rays) the bone may be removed by a longitudinal incision, which begins on the anterior aspect of the fibula, a hand's breadth above the ankle joint, and extends downwards over the outer surface of the astragalus to the base of the fifth metatarsal bone. The incision enters the ankle and mid-tarsal joints and exposes the head and body of the astragalus. The capsule of the joint must be thoroughly separated from the neck of the bone, and the next most important step is the severance of the strong interosseous calcaneo-astragaloid ligament. The remaining ligamentous connections having been divided and the foot forcibly inverted, the bone is cleared and delivered.

Jacobson recommends a transverse incision between the malleoli, with division and subsequent suture of the tendons.

**Excision of the Os Calcis (Calcaneus).**—In tuberculous disease it is usually sufficient to enlarge any existing sinus or to make an incision over the bone, preferably on its outer aspect, and by means of the spoon and gouge to clear out the diseased marrow and spongy bone, after which the cavity is packed and treated by the open method until it fills up from the bottom.

For sarcoma, the entire bone must be removed along with its periosteum. The incision recommended by Farabœuf begins at the base of the fifth metatarsal bone, and is carried horizontally backwards just above the border of the sole, passing round the posterior aspect of the heel to the posterior part of the greater tuberosity of the os calcis. A vertical incision, parallel to and a little in front of the tendo Achillis, meets the horizontal one on the inner aspect of the heel.

The tendo Achillis is detached posteriorly, and the joint capsule at the posterior and outer aspect of the os calcis together with the calcaneo-fibular band of the



external lateral ligament is divided. The peroneal tendons are drawn upwards, the interosseous ligament between the os calcis and the astragalus is cut across, and the dorsal and plantar calcaneo-cuboid ligaments are detached. The point of the heel is drawn well over to the inner side to expose the tendon of the tibialis posticus, which is then displaced upwards and over the sustentaculum tali. Lastly, the os calcis is seized with



FIG. 81.—Kocher's J-shaped incision for Arthrotoomy of Ankle.

a strong pair of forceps, and the internal lateral ligament of the ankle joint, the subjacent calcaneo-astragaloid capsule, and anteriorly the ligaments connecting the tibia with the scaphoid and os calcis are detached (Kocher).

Landerer recommends a mesial longitudinal incision extending from the tendo Achillis over the heel into the sole of the foot. By this incision he removes not only the os calcis but, if necessary, the other bones of the tarsus. He asserts that the scar does not interfere with walking.

**Arthrotomy, Arthrodesis, and Excision of the Ankle Joint.**—In operations for tuberculous disease, free access must be obtained to all parts of the ankle joint, to the joint between the astragalus and os calcis, and, if possible, also to the sheaths of the peroneal tendons (Stiles).

The external hooked incision of Kocher best fulfils these

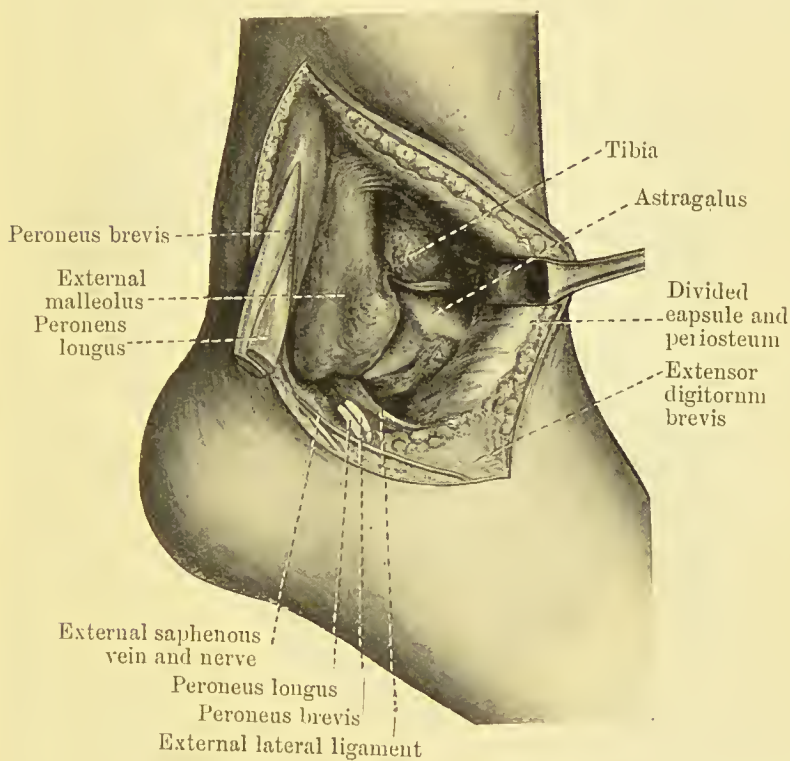


FIG. 82.—Excision of Right Ankle by Kocher's incision, 1st stage.

indications (Fig. 81). It begins a hand's breadth above the external malleolus, about midway between the fibula and the tendo Achillis, and curves round the external malleolus, passing fully an inch below it, to terminate at the outer border of the peroneus tertius, thereby avoiding the musculo-cutaneous nerve. The sheaths of the peroneus longus and brevis are exposed and slit upwards behind the fibula as far as the upper end of the wound.

To obtain the best access, the tendons must be divided, but each is secured with silk in order that it may be sutured at the end of the operation. The periosteum is separated from the outer and lower aspects of the external malleolus, and the ankle joint opened into in front of it (Fig. 82). The capsule is detached along the outer surface of the astragalus, and the three bands of the

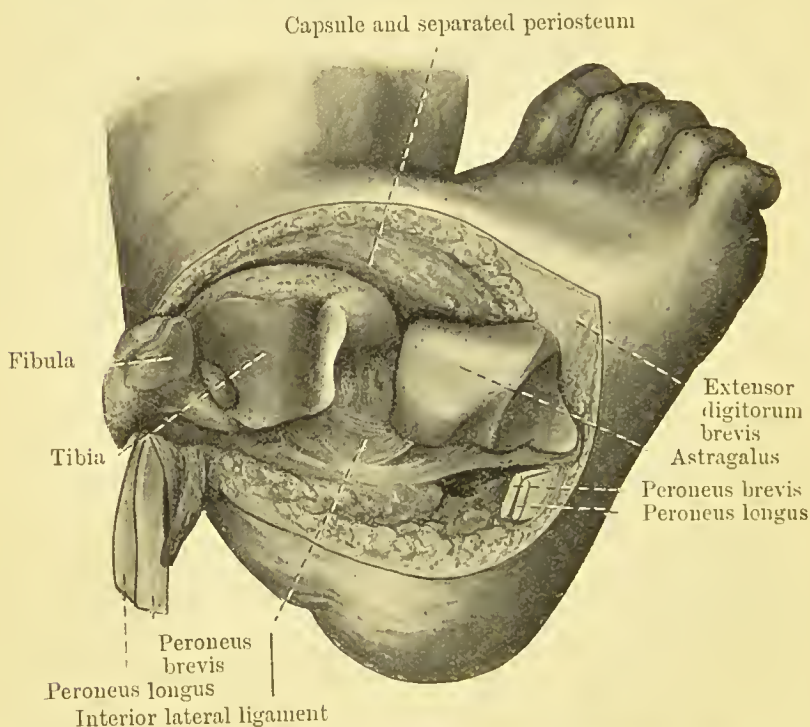


FIG. 83.—Excision of Right Ankle by Koehler's incision; the foot is dislocated inwards.

external lateral ligament are divided close to their attachments to the external malleolus. The capsule, together with the periosteum, is then separated from the anterior border of the tibia as far as the internal malleolus, and the flap, including the extensor tendons, is hooked upwards. The structures on the back of the fibula are also separated subperiosteally so as to leave the tendon sheaths of the peronei in relation to the

periosteum (Fig. 82). The foot is now forcibly dislocated inwards over the internal malleolus until the sole looks almost directly upwards, as shown in Fig. 83.

This admits of thorough examination not only of the ankle joint, but also of the tibio-fibular articulation, and enables the surgeon to determine whether the astragalus and the astragalo-calcanean joint are so involved in the disease that the whole astragalus must be removed. If the astragalus need not be removed completely, excision of the ankle joint is proceeded with, care being taken to remove all diseased tissue, whether involving the synovial membrane, articular cartilage, or subjacent bone, and to shape the upper surface of the astragalus so that it fits into the tibio-fibular arch. It is rightly claimed by Kocher that this method of operating not only gives ample access to all parts of the joint, but by keeping intact the ligamentous apparatus upon the inner aspect of the joint as well as the support of the external malleolus on the outer aspect, provides against lateral displacement of the foot.

If the astragalus must be sacrificed, it is freed from its attachments to the anterior annular ligament, the extensor brevis digitorum, the astragalo-scaphoid and deltoid ligaments, and the strong interosseous ligament which binds it to the os calcis must be divided. To ensure union between the tibia and the os calcis without deformity, the upper surface of the os calcis is removed in the form of a wedge with its base directed backwards, and the sustentaculum tali is chiselled off (Stiles).

In the after-treatment, the foot must be kept at right angles to the leg by means of a plaster of Paris bandage, or a box-splint with foot piece.

**Mikulicz' Osteo-plastic Resection of the Foot.—Total Tarsectomy.**—This operation consists in removing all the tarsal bones, and after sawing across the bases of the metatarsals and the lower ends of the tibia



and fibula, bringing the sawn surfaces into apposition, so that the metatarsals assume a vertical position continuous with the long axis of the leg, and the patient walks upon the heads of the metatarsals with the toes dorsi-flexed to a right angle

The details of the operation vary according to whether the soft parts of the heel are intact, or are so diseased that they must be removed.

When the soft parts are intact, the incision begins upon

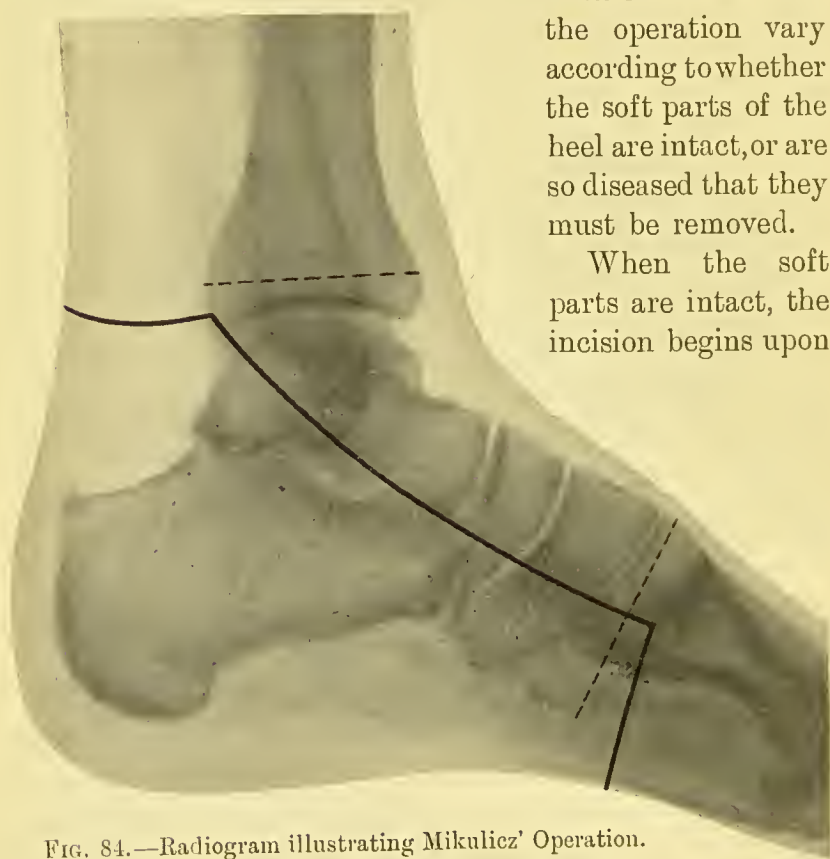


FIG. 84.—Radiogram illustrating Mikulicz' Operation.

the tendo Achillis, a hand's breadth above the ankle joint, passes down behind the external malleolus and peronei tendons, and then forward to the middle of the fifth metatarsal. The tendo Achillis and periosteum are separated from the os calcis, the peronei freed from their sheaths and drawn forwards, and the insertions of all the peronei and both the tibial muscles detached from



the individual bones of the tarsus. The blood vessels and nerves are preserved.

When the skin of the heel is destroyed, a transverse incision is made across the sole from the tuberosity of the scaphoid to a little behind the base of the fifth metatarsal (Fig. 84). A second transverse incision is made on the posterior aspect of the ankle, stretching between the two malleoli. The extremities of these incisions are joined by two others placed one on each lateral aspect of the ankle and foot. The foot is dorsi-flexed and the ankle joint is opened from behind and the soft parts are cleared on the dorsal aspect of the tarsus, care being taken to preserve the *dorsalis pedis* artery, which, through its anastomosis with the external plantar, is the main source of the blood supply to what is to remain of the foot. The anterior section is made well beyond the disease, and the articular surfaces of the tibia and fibula having been sawn off horizontally, the metatarsus is brought into line with the bones of the leg and maintained in this position by wiring the bones. The divided ends of the posterior tibial nerve should be sutured if possible, but this is not of much importance as the intrinsic muscles are of very little use in the altered foot. When the wound is sutured, the soft parts on the dorsum are unduly redundant, but in time the excess of tissue disappears. The desired attitude of the limb should be maintained during healing and convalescence.

**Arthrotomy and Excision of the Knee by Kocher's External J-Incision**—This operation has the advantage of affording access to all the diseased tissues and at the same time retaining the quadriceps extensor apparatus intact.

The incision, which begins over the vastus externus a hand's breadth above the upper border of the patella, passes vertically downwards a finger's breadth external

to this bone, and then curves slightly inwards to end at the anterior border of the tibia just below its tubercle. In the upper part of the wound the muscular fibres of the vastus externus are exposed; lower down is its aponeurotic tendon, which forms that part of the capsular ligament known as the external lateral patellar ligament. These structures along with the subjacent synovial membrane are divided along the whole length of the wound, and the joint is freely opened. The



FIG. 85.—Kocher's external J-incision for Excision of Knee-joint.

insertion of the patellar ligament is next detached along with the tubercle of the tibia and the periosteum immediately below it; in the adult, the tubercle is detached with the chisel; in the child the knife suffices as the tubercle is cartilaginous. The whole of the lower part of the quadriceps apparatus is dislocated to the inner side, and at the same time is turned inside out so that the cartilaginous surface of the patella is directed forwards. The interior of the joint is now freely exposed, especially if the lateral ligaments are detached subperiosteally from the femoral condyles. The anterior ends

of the semilunar cartilages are separated from the tibia and the attachments of the crucial ligaments are divided in order that the leg may be completely flexed.

The *synovial membrane* can now be removed with toothed forceps and knife, aided by scissors curved on the

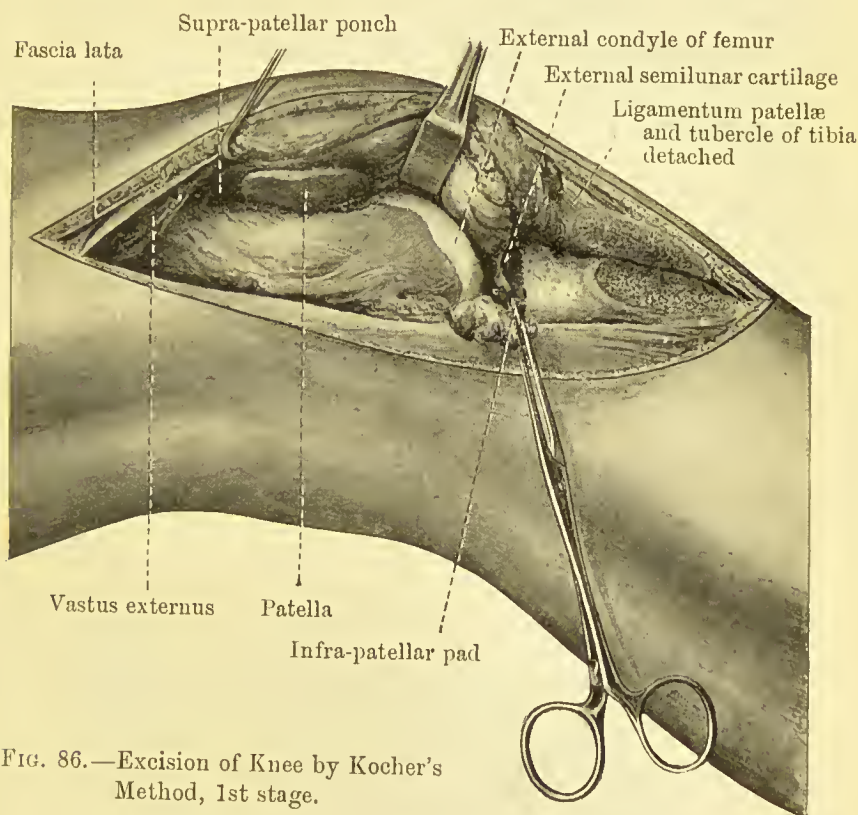


FIG. 86.—Excision of Knee by Kocher's Method, 1st stage.

flat; it is desirable that the upper pouch should be dissected out entire.

The removal of the articular surfaces of the femur and tibia may be carried out with an amputation saw, leaving two flat surfaces, or Kocher's plan may be followed of sawing the tibia concave and the femur convex; whichever method is adopted the sawing must be done in a plane parallel with the articular surfaces. The cartilage of

the patella is now removed with the saw, and a corresponding flat surface is fashioned for it on the femur by sawing off the remains of the prominent external condyloid portion of the trochlear surface of the femur.

The next step is the removal of the remains of the synovial membrane from the back of the joint, and while this is being done the knee should be flexed and the tibia and femur drawn as widely apart as possible so as to stretch out the posterior ligament. The access is improved if the lower end of the femur is drawn upwards and backwards with a strong double hook placed in what remains of the intercondyloid notch. The posterior ligament is freed from synovial membrane and the azygos artery secured and ligated; any tuberculous membrane about the sheath of the popliteus tendon should be followed up and removed, and finally a careful search should be made for any sinus leading through the posterior ligament into an abscess in the popliteal space or into the semi-membranosus bursa (Stiles).

Opinions differ as to the best means of securing fixation of the bones. We believe that when the bones do not fit closely together and there is an undue amount of play between them, fixation of the bones simplifies the after-treatment and favours osseous union. Following Annandale's practice, we have used two long square nails, each driven through the skin over the tibia and through the latter obliquely upwards into the femur. They become loose at the end of three or four weeks and are then easily removed. A large dressing should be applied and fixed by a firm bandage. The limb is secured in a box-splint extending well up to the thigh, or by a long splint like that used by Macewen after his operation for knock-knee. At the end of three or four weeks this is exchanged for a Thomas' knee-splint, which is to be worn for from four to six months. Apart from recrudescence of tuberculosis, the complication



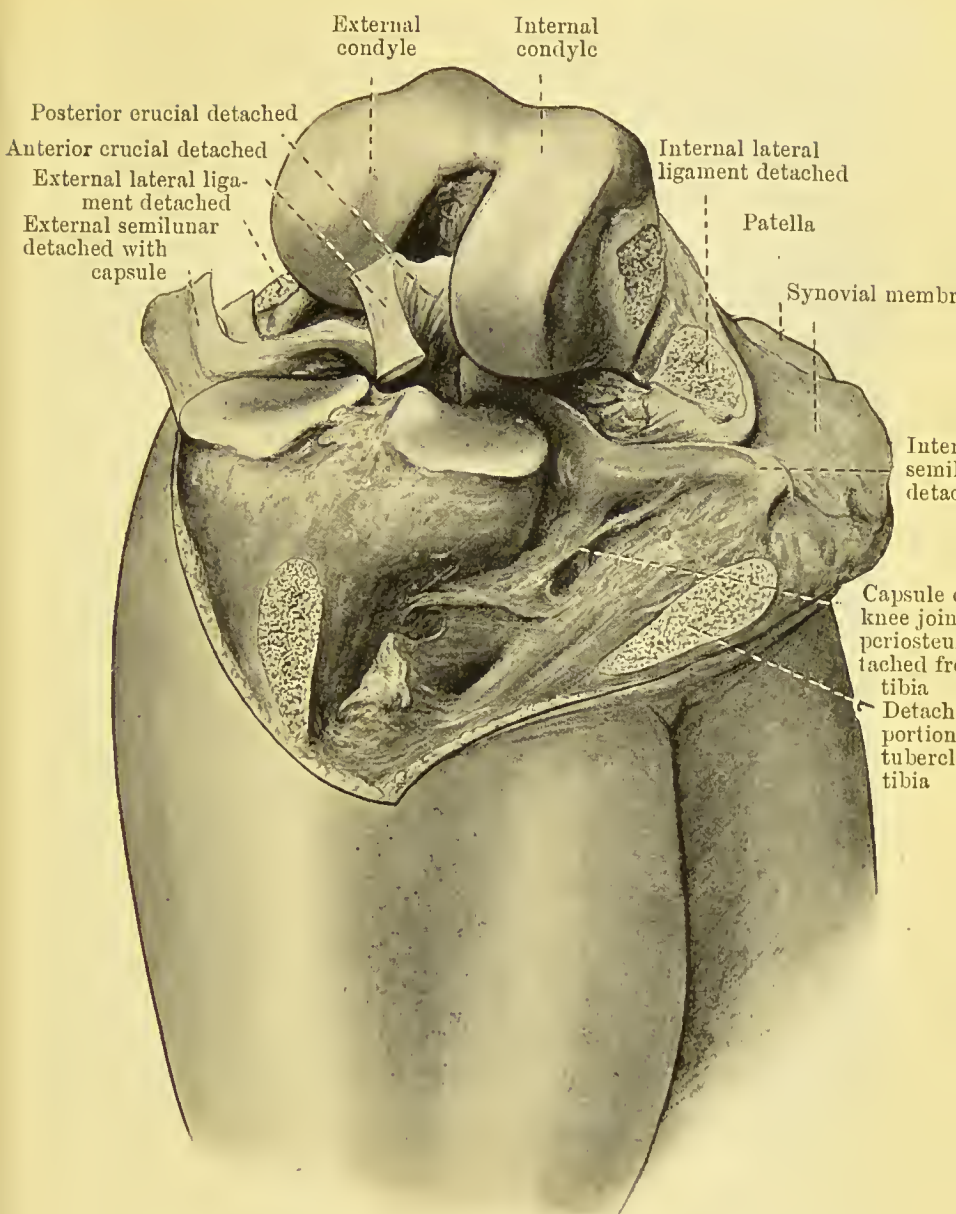


FIG. 87.—Excision of Knee by Koher's Method, 2nd stage.

which most frequently interferes with the success of this operation is the occurrence of flexion or of varum



deformity. They are most likely to occur in children and adolescents in whom the epiphysial cartilages are still actively functioning.

**Arthrotomy of Knee for torn or displaced Internal Semilunar Cartilage.—Meniscotomy.**—In the majority of

cases the lesion of the cartilage is near its anterior end, and the joint is opened in the interval between the patellar and the internal lateral ligaments.

Satisfactory access may be obtained by any one of the numerous incisions that have been recommended: Annandale's incision in the inter-articular interval (Fig. 89); Robert Jones' angled incision along the inner border of the patella; Kocher's J-shaped incision (Fig. 85); or a trans-ligamentary incision (Fig. 88).

When the diagnosis

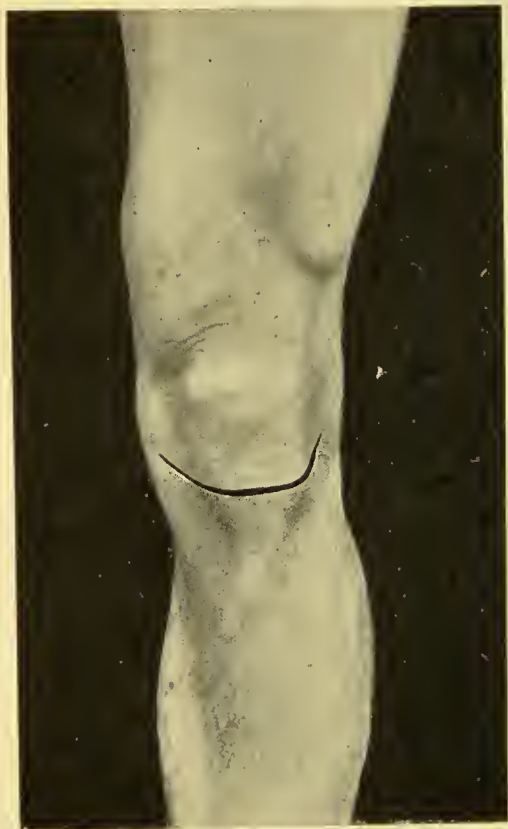


FIG. 88.—Trans-ligamentary incision to expose Knee-joint.

of torn internal cartilage is certain the incision of Annandale or that of Jones suffices; but when, as is frequently the case, the nature of the lesion is uncertain, the trans-ligamentary, or the Kocher incision should be employed, as these give access to all parts of the joint (Fig. 90).

The limb may be held by an assistant in the flexed and slightly abducted position, or the knee may be flexed with the leg hanging over the end of the table, as is recommended by Jones.



FIG. 89.—Annandale's incision for exposing internal Semilunar Cartilage.

The skin incision having been made, the capsule and synovial membrane are opened horizontally above the semilunar cartilage, and to open up the inner side of the joint, the knee is further flexed and the tibia rotated

outwards on the femur. If the cartilage is loose or torn, as much of it as can be reached is removed with a probe-pointed knife. If the cartilage is found to be intact,

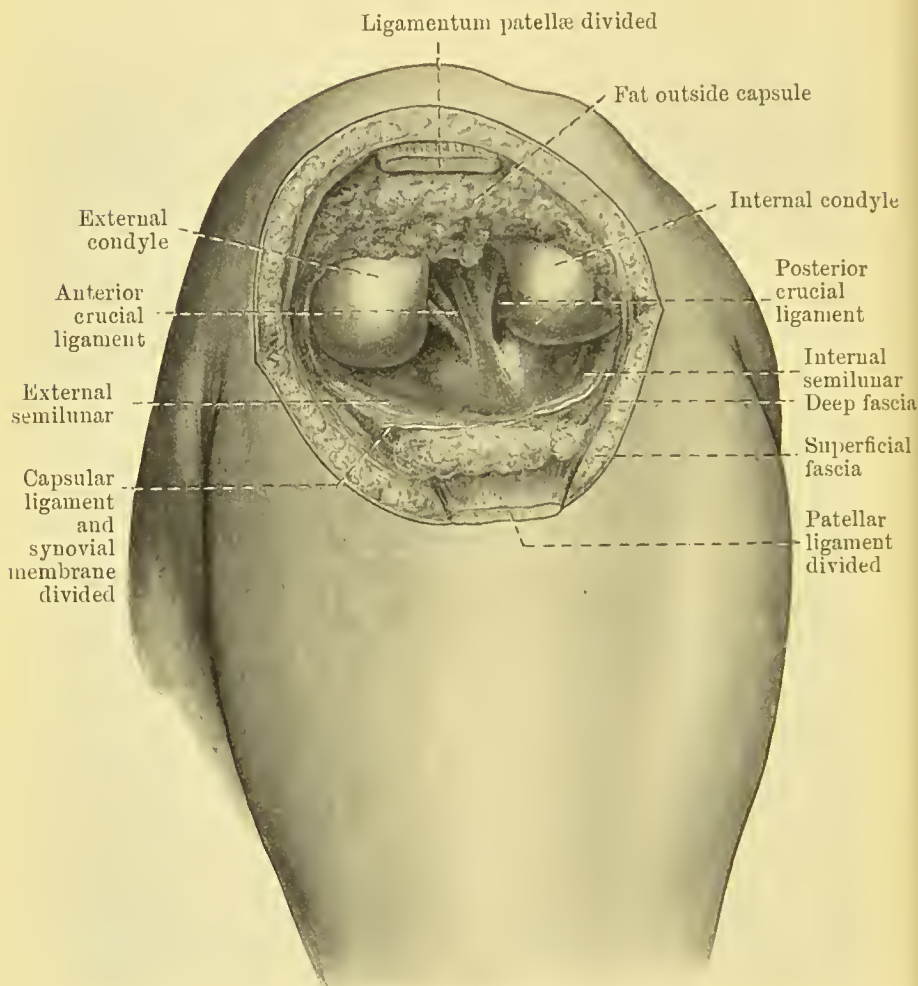


FIG. 90.—Exploration of Knee-joint by Trans-ligamentary Incision.

the joint must be further explored. We have found that flexion and sudden extension of the joint sometimes reveals the cause of the derangement in the form of a loose body or pedunculated tag of synovial membrane.

The lesion having been dealt with, the synovial

membrane and capsular ligament are separately sutured with catgut and the skin wound closed. If there is oozing into the joint, the introduction of a small drain will prevent pain and rise of temperature from tension, but the necessity for this should be avoided if possible by arresting all bleeding by forcible pressure before closing the wound. The application of a posterior splint, such as Heron-Watson's, for the first few days adds to the comfort of the patient.

#### **Operation for Tuberculous Disease of the Patella.—**

When the patella is the primary seat of tuberculosis, the whole bone should be removed to prevent infection of the knee-joint. The skin is divided by a mesial longitudinal incision, and a similar incision is carried through the fascia and the prepatellar bursa; the quadriceps expansion is then separated from the edge of the patella and the periosteum is stripped off the bone, which is then removed. To close the joint and reconstruct the extensor apparatus, the divided structures are brought together in the middle line by sutures.

**OPERATIONS UPON THE HIP JOINT.—Arthrotomy of Hip Joint by Anterior Incision (Hüter).—**This operation is employed to obtain access to the front of the joint for purposes of drainage in purulent effusions, and for fixation of the fragments in fractures. As it affords comparatively little space, it is not suitable when the whole joint has to be explored or when excision is necessary.

The incision, which begins just below the anterior superior spine of the ilium, passes downwards and slightly inwards, dividing the skin and the fascia lata, and entering the muscular interspace between the tensor fasciæ femoris on the outer side and the sartorius and rectus on the inner side. In the lower part of the wound a transverse branch of the external circumflex

artery is usually divided and must be secured. The capsular ligament is opened horizontally, its edges are held apart, and the neck of the bone is exposed.

**Excision of the Hip for Tuberculous Disease by Kocher's**

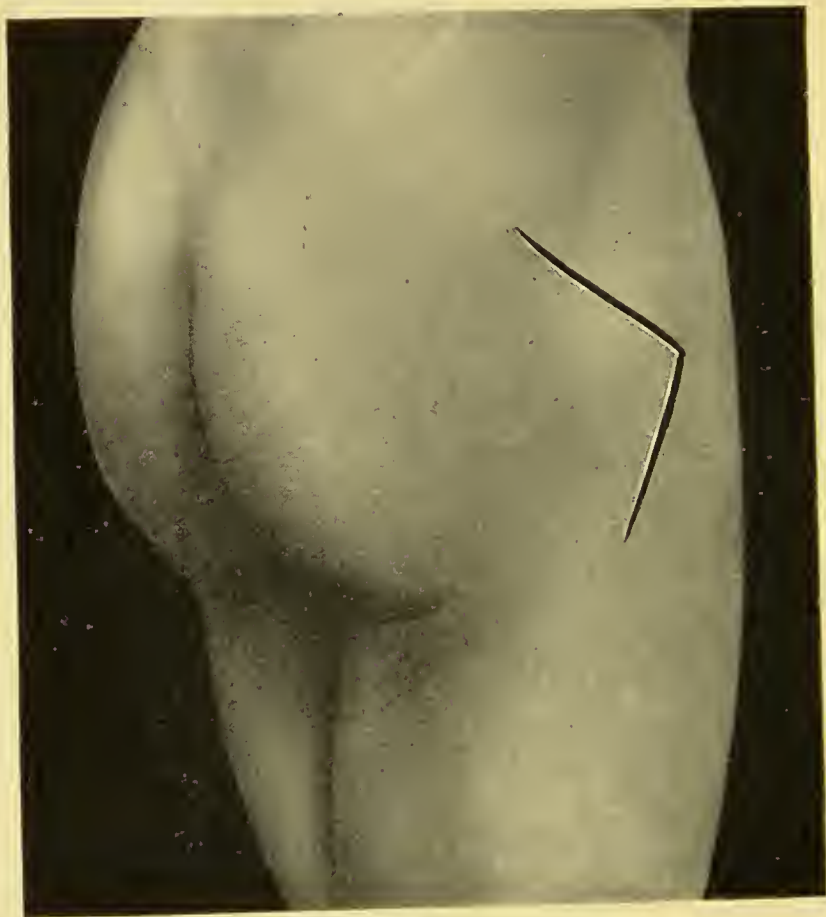


FIG. 91.—Kocher's posterior incision for Disease of Hip-joint.

**Method.**—Kocher's method of exposing the hip-joint from behind has the advantage of affording free access, not only to the head and neck of the femur but also to the acetabulum and synovial lining of the capsule, so that the extent of the disease can be accurately



determined; and if excision is found necessary, it affords ample space for this being done thoroughly.

The patient is placed on his sound side, with the affected limb flexed and adducted; an angular incision

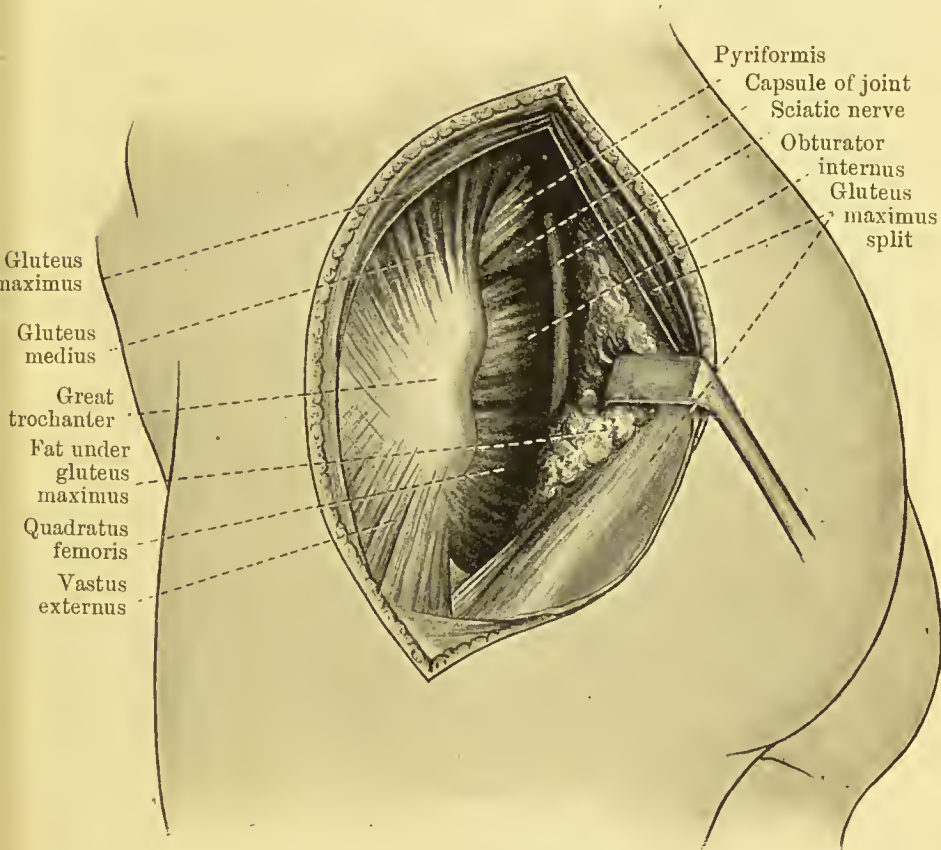


FIG. 92.—Kocher's Operation for Disease of the Hip, 1st stage.

is made, the upper portion extending from the anterior superior angle of the great trochanter upwards and backwards in the line of the fibres of the gluteus maximus, and the lower portion downwards and backwards to the posterior inferior angle of the great trochanter (Fig. 91). The fleshy portion of the gluteus maximus above and behind the trochanter is split in the

direction of its fibres, and the tendinous portion overlapping the trochanter is divided until the upper part of the tendinous origin of the vastus externus is exposed (Fig. 92). On retracting the edges of the gluteus

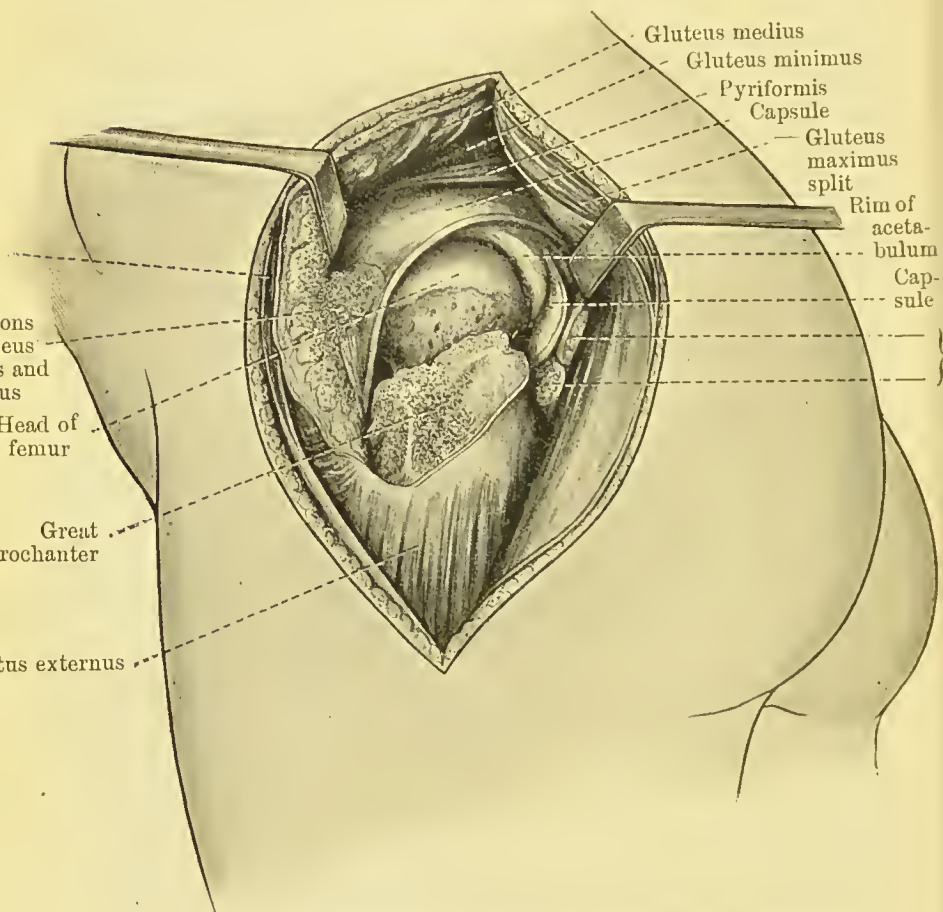


FIG. 93.—Excision of Hip by Kocher's Method, 2nd stage.

maximus, the following structures are exposed from above downwards (Fig. 92): a layer of fatty tissue occupying the hollow above and behind the trochanter, the insertion of the gluteus medius covering the upper and anterior part of the trochanter, and, lower down, the vastus externus. Below the gluteus maximus is the pyramidalis,

and still lower are the obturator internus, the gemelli, and the upper fibres of the quadratus femoris. The sciatic vessels and nerves are not usually exposed.

The next step is to detach the insertion of the gluteus medius from the trochanter; in the child this is easily done with the knife, a slice of cartilage being included with the tendon. In the adult, the hammer and chisel are employed to detach a thin layer of bone along with the tendon (Fig. 93). By retracting the separated insertion of the gluteus medius well upwards and forwards with a double sharp hook, the insertion of the gluteus minimus is reached and may, if necessary, be detached from the anterior border of the trochanter. If the head of the bone is in the acetabulum, the tendon of the pyriformis is also detached from the trochanter and retracted forwards with the glutei, or if the head has been displaced upwards, it is retracted backwards with the obturator internus and gemelli, after they have been detached from the trochanter. The posterior part of the capsule, after being fully exposed, is incised in the coronal plane over the projecting head of the femur; this step is made easier if the assistant flexes, adducts and rotates the thigh inwards, thereby projecting the head of the bone against the capsule. The opening in the capsule is enlarged up to the acetabulum, and down towards the trochanter, and the head of the bone is made to appear through it by rotating the limb further inwards and pushing the thigh vigorously upwards and backwards. If the ligamentum teres is still present, it should be divided at its attachment to the femur; the head is then dislocated backwards and the acetabulum is now accessible.

At this stage the various parts of the joint are carefully examined to determine the nature and extent of the disease. It is usually necessary to remove the head and neck of the bone; for this purpose a Gigli

wire saw or an osteotome is employed, and the sawn section of the remaining portion of femur should be examined in case the disease has extended into the trochanter.

The upper end of the femur having been dealt with, attention is directed to the acetabulum, any diseased cartilage being removed and foci in the bone cleared out with the spoon and gouge. If there is a sequestrum, it must also be removed along with the surrounding tuberculous granulation tissue.

The upper end of the femur is rounded off so as to fit into the bottom of the acetabulum in the abducted position. The diseased synovial membrane is removed with the spoon and scissors, and finally iodoform paste is rubbed into all the raw surfaces. The opening in the capsule and the separated muscles are then brought together with catgut sutures and the skin wound closed without drainage.

It is of the first importance that the limb be maintained in an attitude of abduction, of such a degree that the femur occupies the line corresponding to the original direction of the neck of the bone, the attitude being maintained by Stiles' abduction splint (Fig. 288, vol. i.). To ensure this attitude, it may be necessary to divide the gracilis, adductor longus, adductor brevis, and inner part of the adductor magnus.

When the wound is healed, the abduction splint is replaced by a case of plaster of Paris, extending from the mid-thorax to the instep, in which, wearing a patten on the sound limb, the child is able to get about on crutches. The body weight should not be borne on the unsupported limb until at least six months after the operation.

**Reduction of Congenital Dislocation of the Hip by Open Operation.**—Operation is indicated in cases in which reduction by other methods has failed. The



method usually employed is the Lorenz modification of the operation introduced by Hoffa in 1890—the *Hoffa-Lorenz Operation*.

The child is laid on its back and an incision is made downwards and inwards from the anterior superior spine of the ilium. After the fascia lata has been split, the interspace between the sartorius and rectus on the inner side, and the tensor fasciæ femoris and glutei muscles on the outer side is opened up, and these muscles are widely retracted, until the capsule of the joint is exposed. The joint is then opened sufficiently to expose the whole head and neck of the femur. If more space is required, the muscles may be detached from the crest of the ilium in the immediate vicinity of the anterior superior spine. The remains of the ligamentum teres having been removed, the head of the femur is pulled away from the innominate bone so that the cavity of the acetabulum and the upper part of the capsule may be inspected. If there is a marked constriction of the capsule it should be stretched by a dilator, or divided with a probe-pointed bistoury. If the acetabulum is sufficiently well formed to receive the head of the bone, an attempt at reduction is at once made. If the socket is filled with fibro-fatty material, this must be cleared out with a sharp spoon; if it is too shallow to lodge the head of the bone securely it must be enlarged and deepened by gouges, burrs, or other suitable instruments. The cartilage covering the head of the bone must be preserved in order to obtain a movable joint.

Every care must be taken that the head of the bone is securely lodged in the acetabulum, and that it is not allowed to escape therefrom during the subsequent manipulations. The capsular ligament is closed with sutures, the muscles and the fascia lata brought together, and, on account of the oozing which is usually present, a drain is inserted for twenty-four hours. The limb is



then put up in a plaster of Paris ease in the position of marked abduction. At intervals of about a month the case is renewed, the degree of abduction being diminished each time. In our experience the operation is a difficult one; the results of it should be controlled by X-ray photographs.

**Operations for Ankylosis at the Hip.**—In addition to

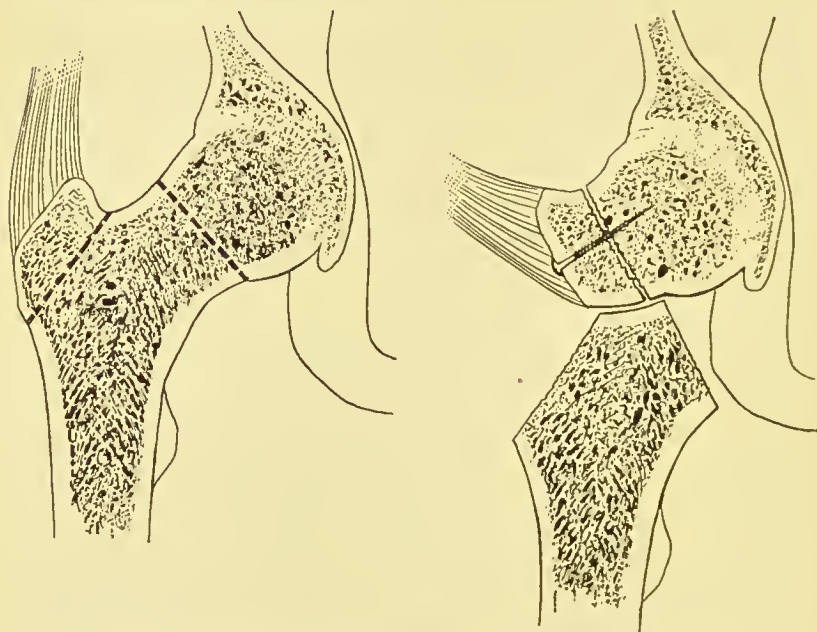


FIG. 94.—Robert Jones' Operation for Ankylosis at the Hip.

those that have been described with Osteotomies (p. 135), mention must be made of the operation devised by Robert Jones for making a false joint in the position of the neck of the femur (Fig. 94). It is especially suitable for those cases of tuberculous disease which have resulted in ankylosis in a bad position, and in which the head and neck of the bone have been preserved. A longitudinal incision is made with its centre at the upper border of the great trochanter, and a second incision divides the periosteum across the base

of the trochanter just below the insertion of the gluteal muscles. A slice of the trochanter from this point to its junction with the neck above is separated with a wide osteotome and retracted upwards. The capsule is opened and the neck separated from the head with the osteotome. Extension is now applied to the femur, and the trochanter with its muscles attached is fixed to the head of the bone, which remains in the acetabulum.

**Operation for Disease of the Ilium and Sacro-iliac Joint.**—Kocher quotes Sprengel as having devised an incision which gives free access to the outer surface of the ilium and to the upper and posterior parts of the acetabulum. It is carried along the crest of the ilium to the anterior superior spine, whence it passes downwards into the thigh between the tensor fasciæ femoris, and the sartorius. The gluteal muscles and the periosteum are stripped off the ilium from above downwards with a sharp-edged instrument, forming a flap which can easily be replaced. Access to the *sacro-iliac joint* is obtained by an incision commencing at the posterior iliac spine and carried along the crest of the ilium. The muscles and periosteum are stripped as in the preceding operation, and by means of the chisel or saw, the posterior part of the ilium is removed. In the majority of cases there is an abscess which must also receive attention.

## OPERATIONS ON BONES AND JOINTS OF THE UPPER EXTREMITY

**Fingers and Hand.**—To avoid the arteries and nerves, and the tendons, incisions must, if possible, be made on the lateral aspect, and the further they extend towards the tip of the fingers the nearer must they be to the dorsum.

Towards the base of the first phalanx, it is better, when a choice is possible, to make the incision on the ulnar aspect, because the lumbrical muscles wind towards the radial aspect.

In the hand, special care must be taken to avoid the superficial and deep palmar arches. As landmarks for incisions in the region of the wrist, there are: the pisiform bone with the insertion of the flexor carpi ulnaris, on the radial side of which may be felt the ulnar vessels and nerve; below the pisiform bone and to its ulnar side, lies the projecting body of the unciform bone, upon which the dorsal branch of the ulnar nerve can be felt; a thumb's breadth below and somewhat to the radial side of the pisiform is the hook of the unciform, below which curve round the deep branches of the ulnar artery and nerve; the superficial sensory division of the ulnar nerve can be felt through the skin and rolled from side to side over the hook of the unciform; lastly, immediately above the ball of the thumb is the projection of the trapezium, over which the superficial volar branch of the radial artery descends to complete the superficial palmar arch.

For access to a **metacarpal bone**, a dorsal incision is employed.

**Excision of the Wrist** (Fig. 95).—We shall here describe the operation by a single ulnar incision, which was practised by Patrick Heron-Watson; its chief merits are its simplicity and the unobtrusiveness of the scar. The classical methods of Lister, Langenbeck and Kocher are described in the larger works on Operative Surgery.

The incision commences over the ulna about two inches above the styloid process, and passes downwards between the tendons of the extensor and the flexor carpi ulnaris to the middle of the fifth metacarpal bone on its ulnar aspect. The extensor carpi ulnaris is cut near its insertion into the base of the fifth metacarpal and

raised with the skin and other soft parts on the dorsum, and the common extensor tendons are raised and the whole of the dorsal aspect of the carpus denuded. The next step is to clear the palmar aspect of the lower end

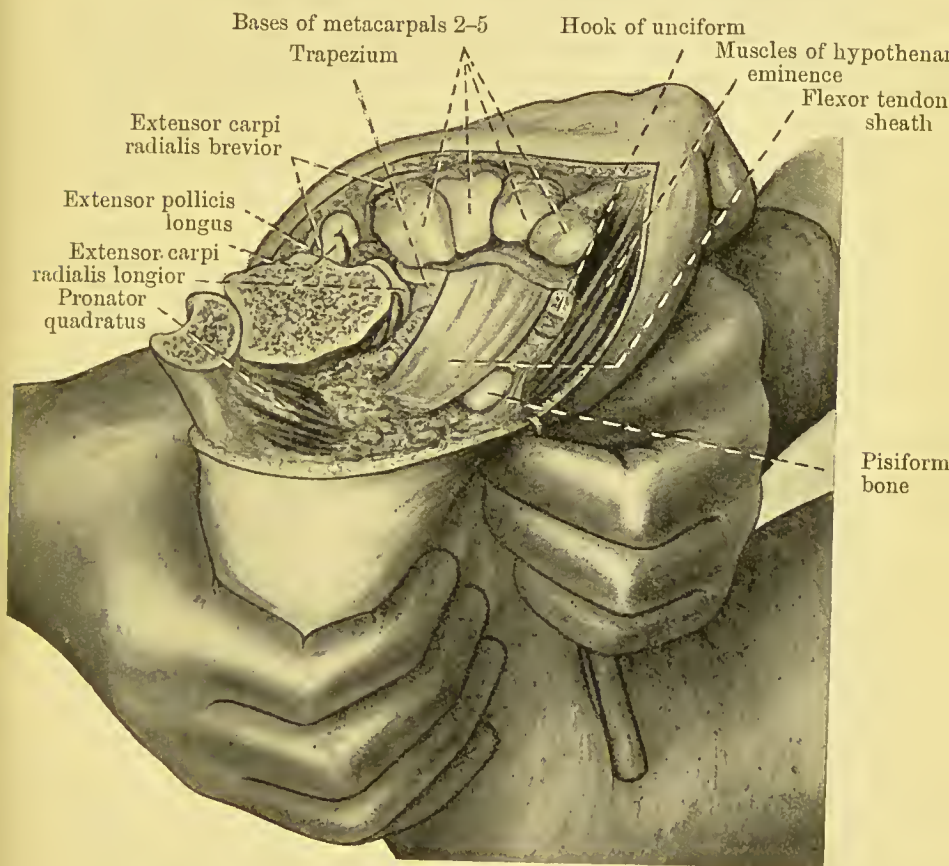


FIG. 95.—Excision of Right Wrist by Single Ulnar Incision.

of the ulna and the carpal bones, and in doing this the pisiform and the hooked process of the unciform are severed from the rest of the carpus, the former by dividing its capsular ligament with the knife, the latter with cutting pliers. The lower end of the ulna is then cleared, protruded from the wound, and cut across with the wire saw. The bones of the carpus are now removed



seriatim with the pliers or gouge; the trapezium, however, if healthy, may be left.

The lower end of the radius is next cleared and protruded at the wound, and a slice removed with the wire saw; the bases of the second, third, fourth and fifth metacarpals are similarly dealt with, but the base of the first, if healthy, may be preserved. The wound is closed, except in cases in which there is mixed infection when it is packed throughout with iodoform worsted, which need only be changed at intervals of from ten to fourteen days.

Throughout the after-treatment the hand must be maintained in the attitude of marked dorsiflexion, while the phalanges are flexed towards the palm. We have not found the splint introduced by Lister for this purpose so efficient as a shaped splint made of thin metal, which may be replaced later by a moulded wristlet.

As the aim of the operation is to secure close fibrous ankylosis between the metacarpus and the bones of the forearm, and to preserve the movements of the fingers, active and passive movements must be commenced early and persevered with throughout.

**Arthrotomy and Excision of the Elbow.**—For tuberculous disease, Kocher's method deserves the preference because it gives the freest access to the joint with the least interference with the muscles and their nerve supply. With the elbow almost completely extended and resting on its ulnar border on the chest of the patient, an incision is made, beginning at the external supra-condyloid ridge two or three fingers' breadth above the level of the joint, passing vertically downwards to the head of the radius, and thence along the outer border of the anconeus to the posterior border of the ulna, about three inches below the tip of the olecranon, and finally curving inwards over the inner surface of the ulna (Fig. 96). The upper part of the incision sinks in between the brachio-



radialis and the radial extensors in front, and the triceps behind. In its lower part it passes down to the bone, between the extensor carpi ulnaris and the outer border of the anconeus, and divides the strong capsule over the head of the radius. It will be observed that the incision corresponds accurately to the interval between the muscles supplied by the branches of the musculospiral and those supplied by the posterior interosseous. The outer head of the triceps, with the periosteum and upper part of the capsule are detached subperiosteally



FIG. 96.—Kocher's External Incision for Excision of the Right Elbow.

from the humerus, the anconeus from the posterior surface of the ulna, the insertion of the triceps from the tip of the olecranon, and on the joint being extended, the combined flap of triceps and anconeus is displaced over the olecranon to its ulnar side (Fig. 97).

The external lateral ligament, the attachment of the extensor tendons, and the capsule attached to the external condyle, are separated subcortically by a sharp instrument and drawn forwards. The joint has now become so movable that the forearm can be completely dislocated inwards and yet the extensor apparatus is preserved in

its continuity and the internal lateral ligament is still intact. If complete resection is to be performed, the internal lateral ligament is separated along with a shell

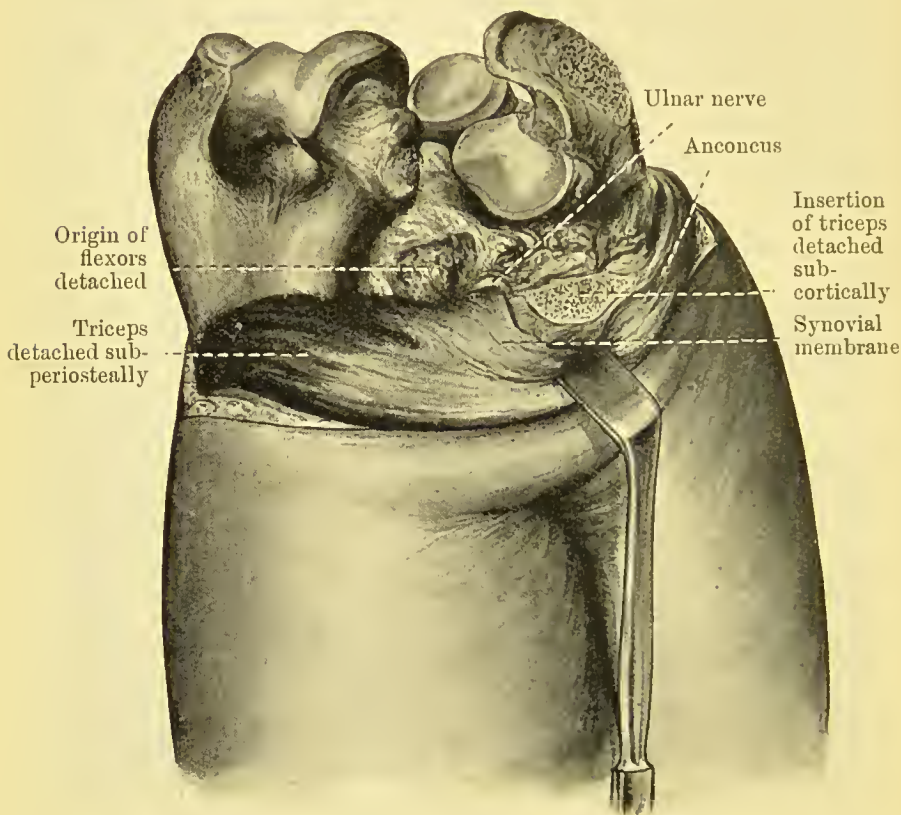


FIG. 97.—Excision of Elbow by Kocher's Method.

(The clearing of the humerus is in excess of requirements.)

of bone, and the ends of the bone cleared for the application of the saw. The olecranon should be sawn in a curved direction in order to preserve the attachment of the triceps.

Kocher places the limb so that the radius and ulna are in contact with the humerus, and the forearm is held upright by means of a curved splint. We are in the habit of putting the forearm midway between pronation

and supination, and in an almost straight line with the upper arm. When the wound has healed, the limb, although extended during the night, should be supported with a sling in the flexed position during the day. Active movements, guided by an elastic apparatus or the traction of a weight over a pulley, should be commenced as early as possible.

When operating *for ankylosis* at the elbow, and in cases of tuberculosis in which the disease is confined to the olecranon, the median posterior longitudinal incision of Langenbeck, with splitting of the triceps, is to be preferred.

The operation for *arthroplasty* at the elbow is illustrated at p. 149.

**Arthrotomy and Excision of the Shoulder.**—The best access to the shoulder joint is obtained from the front. The incision begins upon the clavicle, above the coracoid process, and passes downwards and slightly outwards along the anterior border of the deltoid. The cephalic vein is drawn inwards along with the pectoralis major muscle and the deltoid is drawn outwards (Fig. 98); the access may be improved by dividing some of the fibres of the deltoid close to the clavicle, and the descending branch of the acromio-thoracic artery must usually be secured.

The coracoid process and the muscles attached to it—the pectoralis minor, the coraco-brachialis, and the short head of the biceps—are well seen, and at the outer border of the last named, the sheath of the long head of the biceps is opened, and the tendon thus freed is drawn inwards to give access to the upper end of the humerus. The tendon of the subscapularis inserted into the lesser tuberosity is brought into view by rotating the humerus outwards, and along with the capsule is separated from the bone subcortically. By rotating the humerus inwards the supra- and infra-spinatus and the teres minor muscles,

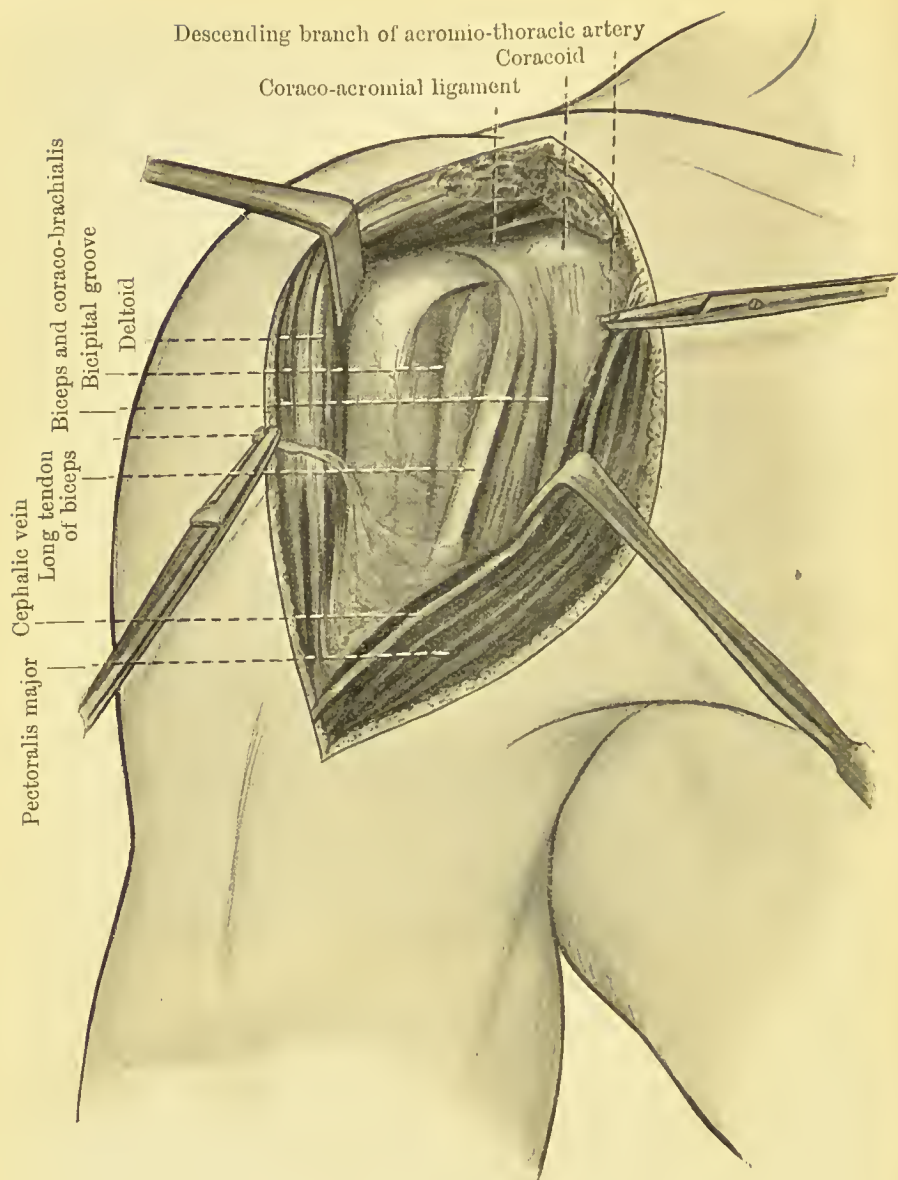


FIG. 98.—Excision of Right Shoulder by the Anterior Incision,  
1st stage.

inserted into the greater tuberosity, are similarly exposed and separated. It is now possible to project the head of the bone from the wound and to investigate the



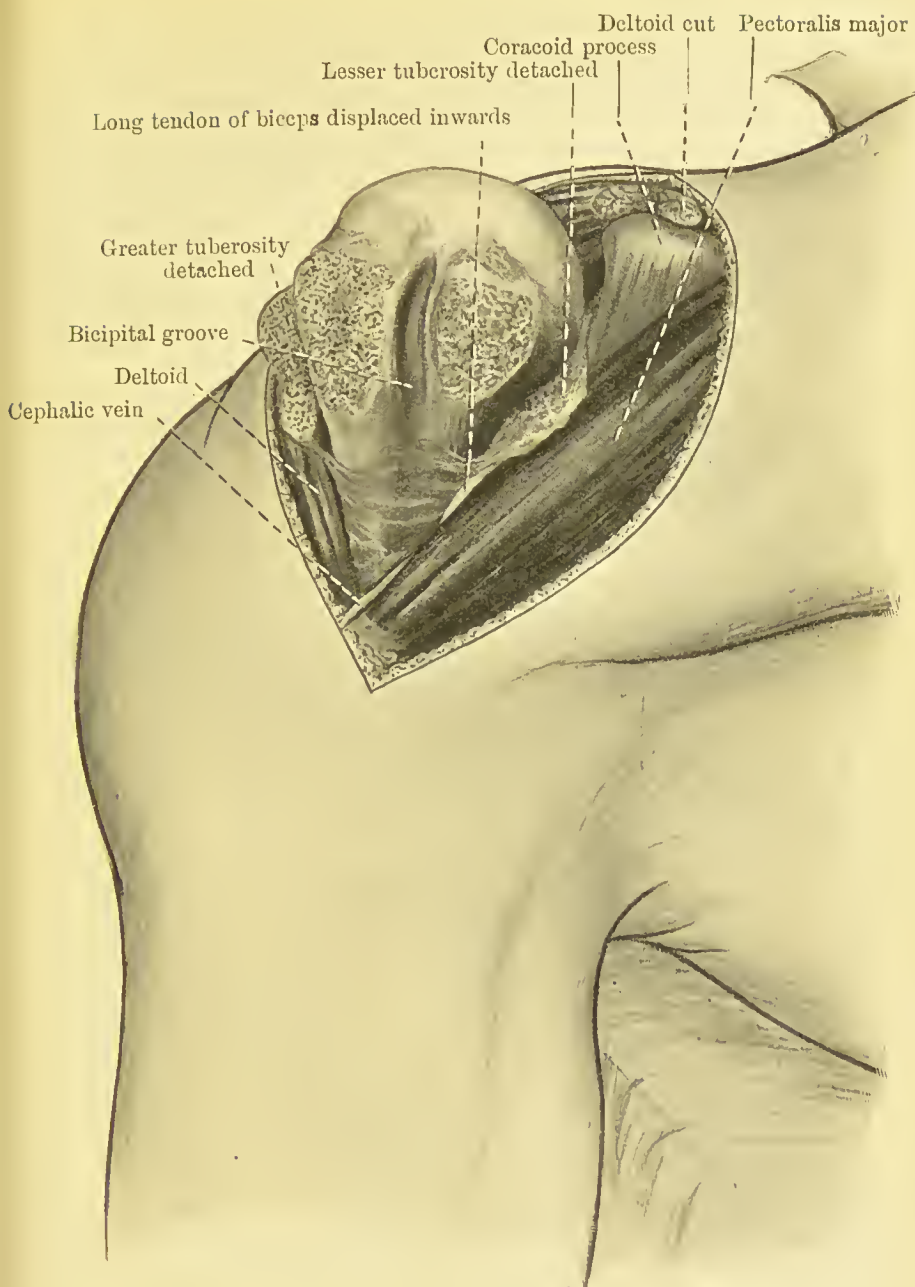


FIG. 99.—Excision of Right Shoulder-Joint by Anterior Incision, 2nd stage.  
condition of the synovial membrane and articular surfaces of the humerus and the glenoid (Fig. 98).



If the disease in the humerus is superficial, the cartilage is merely pared or curetted; if more deeply situated, the head is removed in the line of the anatomical neck. The glenoid is similarly dealt with. If drainage is called for, a dressing forceps is pushed through the posterior capsule and brought out through the skin opposite the posterior border of the deltoid; a rubber tube is then seized and pulled into the joint. The divided capsule and separated muscles are stitched with catgut and the wound closed.

The arm is put up in the attitude of right-angled abduction and is maintained so for two to three weeks. The angle is then gradually reduced and the forearm supported in a sling.

Catterina has shown that access to the joint from the front may be improved by prolonging the incision upwards over the clavicle and dividing this bone at the junction of its outer and middle thirds, and dislocating the outer portion backwards along with the deltoid. This method may be employed with advantage in cases of old - standing sub - coracoid dislocation of the humerus.

#### **Operation for Recurrent Dislocation of the Shoulder.—**

The shoulder-joint is exposed from the front, as already described. If the edges of the wound cannot be sufficiently retracted it may be necessary to divide some of the muscles in order to obtain free access. Mattress sutures are then inserted through the capsule so as to raise a vertical fold or tuck (Fig. 101). An alternative is to incise the capsule and overlap the edges in bringing them together. Openshaw recommends that the subscapularis should be detached from its insertion into the lesser tuberosity and united to the deltoid. These operations are easily performed on the cadaver, but in a muscular patient the parts to be dealt with are difficult of access (Fig. 101).

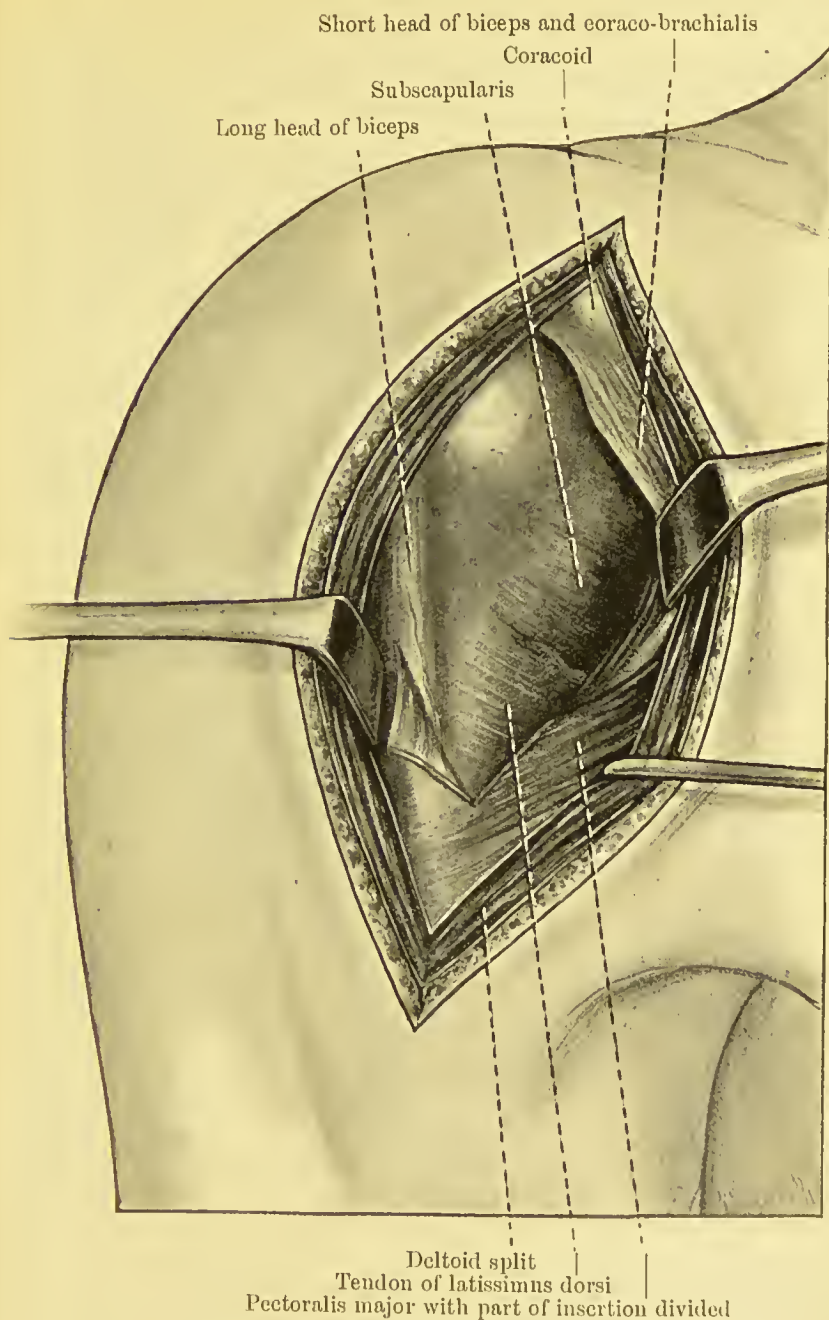


FIG. 100.—Operation for Recurrent Dislocation of Right Shoulder, 1st stage.

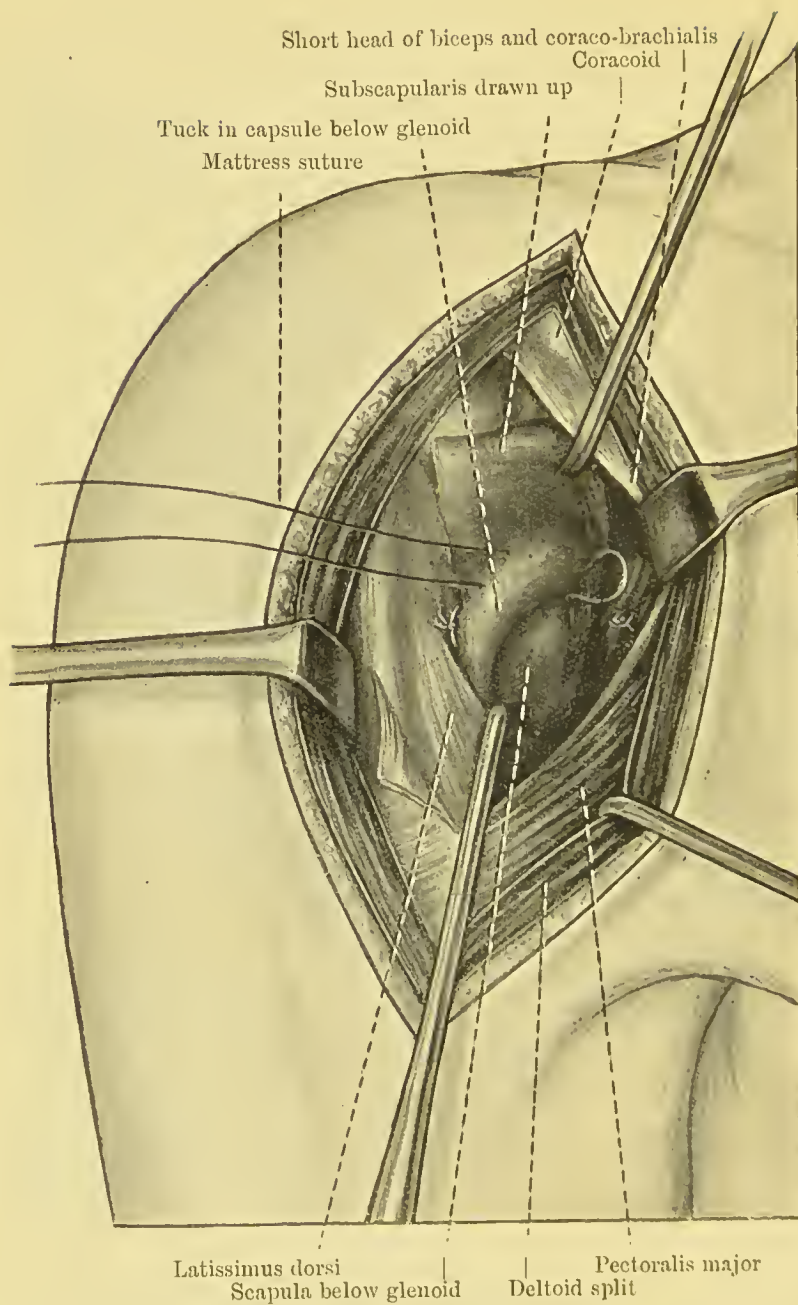


FIG. 101.—Operation for recurrent Dislocation of Right Shoulder,  
2nd stage.

**Resection and Total Excision of the Scapula.**—When suppurative or tuberculous disease has resulted in necrosis of a part of the scapula, it is usually possible by enlarging existing sinuses to obtain sufficient access for the removal of the sequestrum and infected granulation tissue. The periosteum being preserved, there is abundant formation of new bone and the restoration of function is usually complete.

When the scapula is the seat of tumour growth, not only the periosteum but also the surrounding muscles must be sacrificed, and movements at the shoulder-joint may be permanently lost. The operation thus becomes one of considerable severity. A slightly curved incision is made along the acromion and spine of the scapula to meet a second one running the whole length of the vertebral border. If the whole acromion is to be removed, the trapezius and deltoid muscles are cleared from it and the acromio-clavicular joint opened. If a portion of the acromion is to be preserved, the muscular insertions are retained and the bone is divided with the saw or chisel at the point selected.

The lower triangular flap is reflected as far as the upper edge of the latissimus dorsi; the finger is introduced under the exposed border of the deltoid, and the muscle divided close to the spine and acromion.

If the glenoid portion of the scapula can be retained, muscle after muscle is cut across, and an elevator or a finger introduced between them. If, however, the glenoid must be removed, the tendons are detached from the head of the humerus as in excising the joint,—namely, the spinati and teres minor from the greater tuberosity, the subscapularis from the lesser tuberosity, and farther down the insertions of the latissimus dorsi and teres major from the inner bicipital ridge.



The circumflex nerve and the posterior circumflex artery are to be avoided, or the latter may have to be ligated at the lower border of the *teres minor*, while farther back the *dorsalis scapulæ* artery must be ligated.

To divide the *trapezius*, the finger is introduced beneath it, and the muscle is detached along the *acromion* and spine. The *acromial* branches of the *acromio-thoracic* artery will require to be ligated in separating the anterior part of the muscle.

The *scapula*, which has now become movable, is drawn downwards, and the muscles attached to the *coracoid* process, the *omo-hyoid* at the upper border, and the *levator anguli scapulæ* at the upper angle, divided, the *supra-scapular* artery being secured at the upper border of the bone, and the posterior *scapular* at the upper part of the vertebral border. The attachments of the *serratus magnus* and of the *rhomboids* at the vertebral border are cut across and the bone is removed.

In the after-treatment an attempt should be made to provide a fixed point for the head of the humerus. The head must be fixed by stitching the capsule and any available stumps of tendons to the clavicle. The muscles attached to the *coracoid* process are also sutured to the clavicle. The upper border of the *deltoid* is stitched to the *trapezius* and adjacent muscles. The arm should be placed in the attitude of hyper-abduction.



## CHAPTER XII

### AMPUTATIONS

INTRODUCTION. GENERAL CONSIDERATIONS. ESSENTIALS OF A GOOD STUMP: *In lower extremity; in upper extremity.* UNDESIRABLE FEATURES IN A STUMP. METHODS OF AMPUTATING: Incisions—Methods of forming flaps—Choice of Method. TECHNIQUE OF AMPUTATING: Tourniquets—Steps of Operation—Concluding Steps of Operation—After-treatment.

**Introduction.**—Any surgical procedure which involves the removal of the whole or part of a limb is conveniently spoken of as an “amputation.” For descriptive purposes, however, it is customary to apply the term “amputation” to an operation in which the limb is severed between two joints and the bone is divided; the term “disarticulation” being employed when the separation is effected by passing through a joint.

The advances which have been made in general therapeutics, the greater attention paid to morbid conditions in their early stages, and the improvements in conservative operative measures now render it possible to cure many affections which previously necessitated amputation. The improved conditions of industrial life, and the precautions taken to protect work-people from injury have greatly diminished the number of accidents which call for amputation, and the improvement in technique and other advances in conservative surgery enable many injured limbs to be saved which previously would have had to be sacrificed.

The use of anæsthetics and the employment of accurate means of preventing hæmorrhage have abolished the necessity for great rapidity in amputating, and have led to the abandonment of methods which were formerly employed solely because they rendered it possible to sever a limb from the body in so many seconds.

The reasonable certainty of maintaining asepsis in the wound has led to the evolution of certain osteoplastic methods of amputating, some of them being a little more complicated and tedious than a simple severance of the tissues, but yielding a stump of greater functional efficiency.

**General Considerations.**—In deciding upon the propriety of amputating, and in planning the operation, it is necessary to consider:—

1. The nature of the lesion for which the operation is performed—whether for injury or disease. In either case, all the grossly damaged tissue must be removed, and in rapidly spreading infectious and in malignant disease a considerable margin should be allowed beyond this.

2. Whether it is an upper or a lower extremity that is involved. There is always greater hesitation in sacrificing even a portion of the arm than of the leg, and risks may be run in the attempt to save an upper extremity which would not be justifiable in the case of the lower. In the lower limb the operation should be designed to furnish a broad, weight-bearing stump; in the upper, every effort must be made to save as much of the limb as possible, and to conserve its movements.

3. In young patients the recuperative powers of the tissues justify conservative measures which could not be safely employed in older subjects. In young subjects the flaps should be proportionately longer than

in adults, otherwise the continued growth of the bone may result in the development of a conical stump.

4. The general condition of the patient, his ability to stand the strain of a prolonged confinement to bed, his occupation and social position, may determine whether an attempt should be made to save an injured or diseased limb, or whether it should be sacrificed. These factors have also to be borne in mind in selecting the site and method of amputation.

**The Essentials of a Good Stump.**—The objects of the operation being to remove the injured or diseased part, and to provide the best possible stump, it is necessary here to consider the essentials of a good stump, so that the amputation may be planned in such a way as to secure that the portion of limb retained will be useful.

*In the lower extremity* the primary function of the stump is to bear the weight of the body through the medium of an artificial limb. The satisfactory performance of this function depends less upon the length of the stump than upon the breadth of its terminal part. All amputations in the lower extremity, therefore, should be planned so as to secure a broad end to the stump, and in some cases this is best effected by one or other of the osteoplastic operations to be described later. Further, the end of the stump should, if possible, be covered with skin which is accustomed to bear pressure, and in any case the skin should be movable over the end of the bone. The scar should not be over the weight-bearing part of the stump, but should, if possible, be placed on the lateral aspect, where it is least liable to be pressed upon. It is an advantage to have a certain amount of muscle and fascia between the skin and the divided end of the bone to act as a pad or buffer. No nerve trunks should be left in the tissues covering the end of the stump, as they are liable

to become incorporated in the scar, or to form "neuromata" which render the stump extremely sensitive.

In the *upper extremity*, as mobility is the first requisite, the longer the stump is the better. In planning an amputation of the arm, the site of insertion of the various groups of muscle should be borne in mind, and as far as possible these insertions should be preserved. A stump which can be pronated and supinated is of greater value than one which can only be flexed and extended. While breadth is of less importance than length, a broad, rounded stump is better than a tapering, conical one. As the end of the stump is not subjected to pressure, there is no objection to the scar being terminal. As in the lower extremity, the nerve trunks should be cut short so that they do not become implicated in the cicatrix, or pressed upon by the artificial limb.

**Undesirable Features in a Stump.**—It may be said that from the functional point of view the presence or absence of infection is of far greater importance in amputations than in other wounds of the extremities. With asepsis and primary healing there result the minimum of scar tissue, the least degree of sensitiveness to pressure, and as early massage and movements can be carried out, the functions of the tissues, and above all the mobility of the soft parts over the bone, are secured and maintained. Suppuration in the wound, apart from delay in healing and all that this implies, results in the formation of scar tissue which is sensitive, of low vitality, and unable to bear pressure; and further, it leads to fixation of the different layers of soft parts to one another and to the bone, thereby robbing the stump of one of its most valuable qualities as a basis of support for an artificial limb.

*Conical Stump.*—One of the commonest errors made by beginners is to cut the soft parts so short that they

cannot cover the bone without tension. If healing occurs under these conditions, further contraction of the skin and muscles during consolidation may result in that undue projection of the bone which characterises the conical or sugar-loaf stump. The apex of the cone is formed by the bone covered either by a sore which refuses to heal or by a thin pellicle of cicatrix very liable to abrasion. This is occasionally met with, from no fault of the operator, in amputations performed through the upper arm and through the leg in children, when an abnormal growth in the length of the bone takes place from the epiphysial cartilage. The treatment of conical stump, whatever its origin, consists in resecting the end of the bone.

## METHODS OF AMPUTATING

No one method of amputating is suitable to all parts of the limbs. The differences in the shape and arrangement of the structures in different parts, as well as the various lesions calling for removal of the limb, and the objects aimed at in designing the resultant stump, necessitate a variety of methods.

The primitive method of dividing all the tissues of a limb at the same level by means of a chopper illustrates the simplest form of amputation. When this was done, the retraction of the soft parts left the bone protruding from the face of the stump, and union was delayed until the end of the bone had been cast off as a sequestrum. To obviate this the soft parts must be cut at a lower level, so as to provide a covering for the bone.

In fashioning the covering for the bone the first incision is carried through the integument (skin and fat), which after division retracts a short distance up the limb; the muscles are then divided at the level of the retracted skin, and they in turn retract.



The skin incision may be made straight round the limb at right angles to its long axis—*circular incision*, or it may pass round the limb obliquely—*elliptical incision* (Fig. 119). In the region of certain joints—for example, the metacarpo-phalangeal, the shoulder, or the hip—a vertical incision in the long axis of the limb is sometimes added to the circular or elliptical cut, converting it into a *racket-shaped incision* (Fig. 118).

Or again, the covering may be outlined by making one or more U-shaped or rectangular incisions of appropriate size (Fig. 115). It is evident that in whichever of these ways the skin is cut, after the muscles have been divided and the bone sawn, the soft tissues will fall over the end of the bone in the form of a “flap.”

A “flap” may consist of integument alone, or of skin and muscles in one piece (Fig. 116). When the osteoplastic method of operating is employed (p. 222) the flap is made up of skin, muscle, periosteum, and a slice of bone adherent to it (Fig. 110).

In some situations the flap is derived from one aspect of the limb—“a single long flap” (Fig. 106); in others “equal flaps” are taken from opposite aspects of the limb, and in others again the flaps are unequal—“long and short flaps” (Fig. 104).

It will be observed that the chief point of distinction between the different methods of amputating lies in the outline of the incision through the skin and fat.

In the *method by circular incision*, to get sufficient covering for the bone, the skin is divided below the level at which the bone is to be sawn at a distance equal to the diameter of the limb at the saw-line. This should be increased to a diameter and a half in the thigh and upper arm, where the retraction of the soft parts is greater than in the leg or forearm, especially in young people, whose

tissues are more elastic and recoil in greater degree. The circular method is best adapted to those segments of the limbs which are cylindrical.

To facilitate the retraction of the integument in conical segments of the limb, after the circular incision has been made a short vertical incision may be carried upwards along each side of the limb, thus forming two equal integumentary flaps, which can be folded back so as to give better access to the subjacent muscles and bone. This is known as the *modified circular method of Syme*.

In the circular method the scar naturally falls opposite the end of the bone, but it may be dragged from this position by the muscles on one aspect of the limb overcoming the opposing group; in the thigh, for example, the hamstrings overcome the extensor muscles and displace the scar on to the posterior aspect.

In the *method by elliptical incision*, the skin and fat are divided in the form of a circle applied obliquely (Fig. 119). The upper end of the ellipse is placed about a finger's breadth below the saw-line, the lower end at a distance from this equal to the diameter of the limb. When the amputation is completed the lower end of the ellipse is brought up to the upper one, and the scar falls on the lateral aspect of the limb. It is the most universally applicable of all methods of amputation and, with the least sacrifice of soft parts, provides an excellent covering for the stump.

In the *method by racket incision* the longitudinal part—the "handle" of the racket—is made on that aspect which gives best access to the main vessels, as in amputating at the hip, or to the joint, as in amputation of the fingers at the metacarpophalangeal joint; the circular part of the incision or "blade" of the racket surrounds the limb at a level which will provide sufficient covering, usually at a distance beyond where the incision commenced equal to the diameter of the limb at

the saw-line, or at the joint through which the disarticulation is to take place. The scar is termino-lateral, but may become lateral as the result of greater contraction on one side. The so-called *lanceolate* or *oval* methods may be described as racket methods in which the handle of the racket is shortened until the method becomes practically elliptical.

In the *flap method* an incision is usually made on two opposite aspects of the limb so as to outline two flaps, and it may be roughly estimated that the length of the combined flaps shall be equal to at least one and a half times the diameter of the limb at the saw-line.

The *advantages* of the flap method are: (1) It can be employed almost universally at any part of either extremity. (2) The two flaps need not be of equal length; indeed, the best results are obtained when one is cut longer than the other. (3) If the soft parts are destroyed by injury or disease to a higher level on one aspect of the limb than the other, by planning unequal flaps the amputation can often be performed at a lower level than would be possible if the circular method were employed. (4) With unequal flaps the scar does not fall opposite the end of the bone, and is therefore not liable to be pressed upon when weight is borne by the stump. (5) The best available covering for the bone can be selected from any aspect of the limb. The long flap should include the skin which is best adapted to bear pressure, and a sufficient amount of muscle to form a padding for the end of the bone.

## TECHNIQUE OF AMPUTATIONS

*Hæmorrhage* is prevented by means of a tourniquet, by digital compression of the main artery above, by clamping (Lynn Thomas) or tying the artery at an early stage of the operation, or by postponing the division of

the main vessels to the last and grasping them with forceps or with the fingers before severing them.

To ensure a satisfactory covering for the bones it is necessary to have an area of integument with a good vascular supply, and to raise it in such a way as not to damage the blood vessels on which its vitality depends. The knife should be held in the "dinner-knife" fashion, and the integument cut at right angles to the surface.

In the *circular method* the knife is made to divide the tissues in successive circular sweeps, first dividing the skin and fat, then at the level of the retracted skin the superficial and at a little higher level the deep muscles, and finally, at a still higher level, the bone is divided with the saw. When practicable the skin is turned up like a cuff before the muscles are divided.

In the *flap method* the point of the knife divides the skin and fat at the base of the proposed flap, and with a sawing movement the flap is outlined, first on one aspect of the limb and then on the other. In raising the integument from the fascia and muscle, or in reflecting a muscular flap, the edge of the knife should always be directed towards the tissue that is to come away, to avoid "scoring the flap," which, by dividing the vessels on its deep surface, endangers its vitality.

A certain amount of muscle should be retained in the covering, and this should be cleanly cut by giving to the knife a sawing movement. The muscles are usually divided from without inwards at the level of the retracted integument. Where the amount of muscle is excessive—for example, in the thigh—it should be bevelled towards the bone; otherwise the amount retained on the limb will be excessive and interfere with the approximation of the skin edges. As the retraction of divided muscle is greater when it is severed far from its attachment to bone than when close to it, in amputating through the thigh, such muscles as the ham-strings

should be cut across at a lower level than the vasti, so that the muscular element in the flap may be at a uniform level.

The method of cutting the soft parts from within outwards—by “transfixion”—which was practised in pre-anæsthetic days, when rapidity of operating was of primary importance, has been largely abandoned. By this method it is difficult to fashion properly rounded flaps and to avoid having a redundancy of muscle in them, and there is considerable risk of transfixing the main blood vessels and slicing them longitudinally. It may, however, sometimes be employed with advantage—for example, in the thigh, after the anterior flap has been raised by dissection, the knife may be made to transfix the limb behind the femur and cut the posterior flap from within outwards. In the forearm also, where there is difficulty in cutting the numerous tendons evenly from without inwards, the knife may be passed under the tendons and made to cut outwards.

*Tendons* should be cut clean across, and should not be drawn out of their sheaths.

The *main blood vessels* should be cut at right angles, usually near the base of the flap in which they lie.

The *nerve trunks* should also be divided at right angles, but before the wound is closed each nerve should be isolated, pulled down for a distance of an inch or more, and cut across with scissors to prevent its involvement in the superficial part of the cicatrix.

The *bone* is divided with the saw sufficiently high to ensure its being completely buried and covered over by the soft parts. It has long been the custom to divide the periosteum at a lower level than the bone, to provide a covering for the latter, and to comply with an indication surviving from the pre-antiseptic days to protect the marrow from any infection which might arise in the wound. The wisdom of this procedure was first



questioned by Hirsch, who maintained that this tubular prolongation of the periosteum was responsible for the sensitive outgrowths of bone which so often interfere with the weight-bearing capacity of a stump. The outcome of this teaching is to bare the end of the bone of its periosteum and scrape out the marrow, and this is now the practice in the clinics of Hirsch, Bunge, and Bier.

In the lower extremity, further measures are taken to improve the weight-bearing capacity of the stump in the various *osteoplastic methods of amputation*. The first and best known of these is associated with the name of Pirogoff, who, in performing Syme's amputation at the ankle, retained a portion of the os calcis in the heel flap and applied it to the sawn surface of the tibia (Fig. 107). Then followed Gritti, who, in amputating above the knee-joint, retained a portion of the patella in the anterior flap and applied it to the sawn surface of the femur (Fig. 114). Bier is chiefly responsible for the extension of osteo-plastic methods to all parts of the leg (Figs. 109-111).

A *tendino-plastic method* is practised by Wilms, the end of the bone being covered by a broad tendon, such as the quadriceps at the knee, or the tendo Achillis at the ankle.

In disarticulations the technique is simpler, there is no fear of bony outgrowths, and the rounded end of the bone, upholstered in cartilage, affords an excellent basis of support.

**The Concluding Steps of the Operation.**—The *blood vessels* are seized with forceps and ligated, beginning with the main artery and vein, which should be separated from one another and freed sufficiently to ensure that the ligature is in no danger of slipping. The larger vessels in the muscles are usually found in the inter-muscular septa. There is often difficulty in apply-

ing a ligature to vessels close to the bone, but the bleeding from these can usually be stopped by torsion or by a catgut suture.

The *museles and tendons* are stitched to one another as far as possible across the face of the stump. Although considerable atrophy of muscle will take place, that which remains provides a better covering for the bone; if stitched over the bone, it prevents undue retraction of the soft parts, and dead spaces in the wound are obliterated. A drain is inserted if oozing is anticipated or asepsis is uncertain. The skin and fat are brought into accurate contact by sutures. The stump is enveloped in a large dressing of cotton wool, firmly bandaged, and fixed to a pillow or to sand bags, or to a moulded splint of sheet lead.

**After-treatment of the Stump.**—To maintain the nutrition and function of the tissues composing the stump, these should be exercised as soon as the wound is healed, by training the patient to contract his muscles, by massage, and passive movements to promote the mobility of the soft parts over the bone.

## CHAPTER XIII

### AMPUTATIONS OF THE LOWER EXTREMITY

AMPUTATIONS OF FOUR SMALLER TOES. AMPUTATION OF GREAT TOE: *Distal phalanx; both phalanges; with metatarsal bone.* AMPUTATIONS THROUGH FOOT: *Tarso-metatarsal (Lisfranc); mid-tarsal (Chopart); Subastragaloid disarticulation.* AMPUTATIONS AT ANKLE-JOINT: *Syme's; Pirogoff's; Mackenzie's.* AMPUTATIONS THROUGH LEG: *By flaps; Osteo-plastic; Farabœuf's.*

**Amputations of the Four Smaller Toes.**—It is seldom advisable to perform a partial amputation of the four smaller toes, as the stump left is so short as to be useless and is liable to become dorsi-flexed, so that it is pressed upon by the boot. The metatarso-phalangeal joints of these toes lie quite one inch above the web; if this anatomical fact is overlooked only the two distal phalanges may be removed.

*In amputating an entire toe* the racket method is to be preferred (Fig. 102). The adjacent toes are held aside and the surgeon secures a firm grasp of the toe to be removed by means of a strand of moist gauze applied as a clove hitch. In the second, third, and fourth toes the handle of the racket is placed in the middle line of the dorsum of the toe, and commences immediately above the metatarso-phalangeal joint—that is, fully an inch above the level of the web—while the blade of the racket encircles the toe at the level of the web. The incision is carried down to the bone, and the disarticulation is best effected from the plantar aspect—the toe being dorsi-flexed. The glenoid

ligament is divided transversely against the base of the first phalanx. The transverse metatarsal ligament, which unites the heads of the metatarsal bones, must not be injured. Two dorsal and two plantar digital arteries are cut in the lateral edges of the wound, and should be secured and ligated.



a



b

FIG. 102.—Amputation of Toes at Metatarso-Phalangeal Joint by Racket Method.

(In the great and little toes the handle of the racket is placed nearer the middle line of the foot.)

In the case of the *little toe* the handle of the racket is placed nearer the middle line of the foot, so that the sear will be out of the way of pressure by the boot (Fig. 102).

If it is necessary to remove the metatarsal bone along with the toe, the handle of the racket extends a short distance above the tarso-metatarsal joint, and after the toe has been encircled the soft parts are separated from the metatarsal bone. If a portion of the metatarsal can

be saved this should be done, and in the case of the little toe the bone-pliers should be applied obliquely to avoid a projection on the outer side of the foot.

**Amputations of the Great Toe.**—The weight-bearing function of the foot depends so much upon the integrity of the ball of the great toe that every effort should be made to conserve this part.

In removing the *distal phalanx* an incision is made down to the bone from the lateral aspect of the first



FIG. 103.—Amputation through Interphalangeal Joint of Great Toe by Plantar Flap.

interphalangeal joint on one side to a corresponding point on the other side, thus inapping out a single plantar flap (Fig. 103). While the assistant forcibly dorsi-flexes the toe, the surgeon separates the flap from the plantar aspect of the phalanx, keeping as close to the bone as possible. When the glenoid ligament is reached, it is cut transversely against the base of the first phalanx and the joint is thus opened; the disarticulation is then completed by cutting straight into the joint from the dorsal aspect.

The operation may be equally satisfactorily performed



in the reverse order,—opening into the joint from the dorsum, and, after dividing the lateral ligaments, carrying the knife along the under aspect of the phalanx and cutting the flap from within outwards.

The two dorsal digital arteries are cut at the corners of the incision.

Amputation at the *metatarso-phalangeal joints* of the great toe is performed by the racket method, the handle being placed along the fibular side of the toe in order that the sear may be out of the way of pressure (Fig. 102). On account of the large size of the head of the first metatarsal with its sesamoids, the blade of the racket should be at the level of the inter-phalangeal joint, so that a sufficiently large flap is formed to cover the bone. If sufficient covering is available the base of the proximal phalanx should be retained, as this makes a better stump.

In other respects the operation is carried out in the same way as that for removal of the smaller toes.

To remove the *great toe with its metatarsal bone*, the handle of the racket incision is carried up to the articulation with the internal cuneiform, and the soft parts are dissected off the bone, or the removal may be effected subperiosteally. It is a great advantage when it is possible to cut across the bone below the level of the joint, as this saves the attachment of the peroneus longus tendon, and adds to the usefulness of the foot. The bone-pliers should be applied obliquely to avoid a projection on the inner side of the foot.

## AMPUTATIONS THROUGH THE FOOT

In amputating at any level through the foot it is desirable to take the long flap from the sole, as the skin there is best adapted to bear pressure, and the tissues on the plantar aspect are thicker and

more vascular than those on the dorsum. Further, it ensures that the cicatrix will lie towards the dorsal aspect, where it will be least exposed to pressure. Every effort should be made to save as much of the foot as possible, and not to interfere with the inter-tarsal joints if this can be avoided, as the longer and more movable the stump is the better will it bear weight and the more easily will it be fitted with a suitable boot. Finally, care must be taken in performing the amputation, and during the after-treatment, that the tendo Achillis is not allowed to pull up the os calcis and bring the foot into the equinus position.

**Amputation through the Metatarsus** may be performed at any level by the elliptical method, the lower end of the ellipse being fashioned from the sole. After the soft parts have been dissected back the bones are divided with the saw.

Amputation through the metatarsus may also be performed on the same lines as Lisfranc's operation at the tarso-metatarsal joint.

**Tarso-metatarsal Amputations.**—*Lisfranc's method* of removing the foot at the tarso-metatarsal line of articulations is as follows. Facing the sole of the foot, the operator fixes the position of the articulations of the first and fifth metatarsals with the tarsus, the former lying an inch in front of the tubercle of the scaphoid, and the latter just behind the projection formed by the base of the fifth metatarsal bone. In operating upon the left foot,<sup>1</sup> the point of the knife is inserted immediately behind the level of the base of the fifth metatarsal and carried along the outer edge of the foot; opposite the necks of the metatarsals the incision is continued across the sole obliquely, parallel with the heads of the metatarsals, and then along the inner aspect of the foot to the level of the joint between the first

<sup>1</sup> For the right foot the incisions are made in the opposite order.

metatarsal and the internal cuneiform (Fig. 104). While an assistant holds the anterior part of the foot, the operator with his left hand raises the flap off the plantar aspect of the metatarsal bones and dissects it back as far as the level of the tarso-metatarsal joint. Grasping the



FIG. 104.—Incisions and line of disarticulation in Lisfranc's Amputation at Tarso-metatarsal Joint.

anterior part of the foot with his left hand, he then forcibly points the toes, and, entering the lateral part of the incision, cuts a convex dorsal flap extending to the middle of the metatarsal bones, and reflects it up to the level of the joints. The knife is then inserted behind the base of the fifth metatarsal, and the three outer metatarsals are separated from the cuboid and external cuneiform; the base of the first metatarsal is next separated from the internal cuneiform, and there only remains the base of the second metatarsal wedged in between the three cuneiforms. To sever these connections, the point of the knife is inserted between the second metatarsal and internal cuneiform, and the

strong interosseous ligament divided. If the foot is now forcibly depressed, a few touches of the knife will divide the tense dorsal ligament and complete the disarticulation.

To avoid the difficulties of disarticulating the base of the second metatarsal, it may be divided with bone-pliers or sawn across (Skey); or the projecting

part of the internal cuneiform may be sawn off (Hey).

The *dorsalis pedis* and the two plantar arteries, and their branches, are secured and ligated, and the flaps are then brought together and sutured.

The operation may be performed, as was done by Hey, by making the dorsal incision first, disarticulating, and then dissecting the bones from the plantar flap. If sufficient covering can be obtained from the sole, the dorsal flap may be dispensed with; this ensures more effectually that the scar will fall on the *dorsum*.

The patient is able to wear an ordinary boot, the anterior part of which is filled with cotton-wool.

**The Mid-tarsal Amputation.**—This operation, associated with the name of Chopart, aims at disarticulating between the astragalus and os calcis posteriorly and the scaphoid and cuboid anteriorly. The astragalo-scaphoid joint is situated immediately behind the tuberosity of the scaphoid, and the calcaneo-cuboid joint midway between the tip of the external malleolus and the base of the fifth metatarsal. The line of these joints is pretty nearly continuous across the foot, with a slight obliquity forwards.

The method of operating is similar to that employed in amputating at the tarso-metatarsal joint. The extremity of the plantar flap extends to a little beyond the middle of the metatarsal bones, and is made slightly longer on the inner than on the outer side, in correspondence with the greater depth of the inner part of the foot. In disarticulating, the joint is most easily entered by dividing the ligaments binding together the scaphoid and astragalus just behind the insertion of the *tibialis posticus*. Although the operation described by Chopart involves disarticulation at the mid-tarsal joint, it is not necessary to adhere rigidly to this; the bones



may be sawn either above or below Chopart's line, as may best meet the requirements of the case. It has been urged against this operation that the scar tends to be displaced by the tendo Achillis drawing up the heel. In our experience, if the wound heals by primary union, and if care is taken during the after-treatment to keep the stump at right angles to the leg, this tendency can easily be obviated, and if the patient is encouraged to walk on the flat of the sole the tendo Achillis is soon stretched and no disability results. To counteract the tendo Achillis we are in the habit of suturing the extensor tendons to the periosteum. We cannot subscribe to the unfavourable opinions expressed regarding this operation. In the Edinburgh school it has long been regarded as an excellent operation, and one which yields an ideal stump. As regards the boot to be worn after the operation, C. W. Cathcart, whose work on this subject did much to bring the operation again into favour, says: "The simplest apparatus is used—a steel in the sole of an ordinary boot, with stuffing in the toes, or simply a stuffing of cork in the front of an ordinary boot where the lost parts should be. Sometimes a leg-gaiter is used to keep the boot on; sometimes the lacing of the boot round the ankle has been enough."

**Subastragaloid Disarticulation.**—In this operation all the bones of the foot are removed except the astragalus. Of the methods available, the racket incision of Malgaigne may be selected as the simplest. The handle of the racket commences at the outer border of the insertion of the tendo Achillis and passes forwards one inch below the external malleolus; the blade encircles the foot at the level of the mid-tarsal joint. The joint between the astragalus and scaphoid is opened from the dorsum, and the knife is passed backwards and slightly upwards beneath the head of the astragalus, so as to divide



the strong interosseous ligament between it and the os calcis. The soft parts are then dissected from the os calcis, first from its upper surface, then from its outer and under surfaces, and lastly from its inner and posterior surfaces. The foot is rotated to facilitate the dissection, and the soft parts are retracted by



FIG. 105.—Incisions for Syme's Amputation.

sharp hooks. Most difficulty is met with in clearing the projecting sustentaculum tali. The stump is an excellent one.

**Amputation at the Ankle-Joint.**—*Syme's Amputation.*—The classical operation is that devised by James Syme (1842) by means of a single flap taken from the heel. The sole of the foot faces the operator, whose left hand grasps the posterior part of the ankle, with the

thumb and forefinger respectively on the malleoli. The point of a strong-bladed knife is entered below the tip of the external malleolus, cutting right down to the bone, and is carried slightly backwards and then across the sole to the corresponding point on the opposite side,—that is, half an inch below and behind the tip of the internal malleolus. If the heel is large and prominent the backward inclination of the incision should be more decided. With the aid of the left thumb the heel flap is dissected off the os calcis by a series of strokes with the knife, made upon the bone and not upon the flap, until the insertion of the tendo Achillis is reached, when the tendon is divided. The operator then grasps the anterior part of the foot with his left hand, forcibly points the toes, and joins the two ends of the incision made for the heel flap by the shortest route across the dorsum. He then opens the ankle joint from the dorsum, remembering that the articulation is half an inch above the tip of the internal malleolus, and divides the lateral ligaments, thus completing the disarticulation. If the articular surfaces of the tibia and fibula are diseased, the lower ends of these bones are cleared and removed with the saw; if not, merely the projecting points of the malleoli are removed, so as not to bear unduly on the heel flap. The dorsalis pedis is secured in front and the two plantar arteries on the inner side of the heel flap.

The sequence of the steps in a Syme's amputation may be reversed, the dorsal incision being made in the first instance, the disarticulation carried out, and then the os calcis dissected off from the heel flap.

The only objection that can be raised to Syme's amputation is that after the heel flap has been brought into position there is a cavity between it and the lower ends of the bones of the leg, in which blood accumulates, whereby infection may be favoured and healing delayed (Fig. 106). This difficulty can easily be overcome by

making a small drainage opening at one edge of the tendo Achillis and inserting a small glass tube. In the

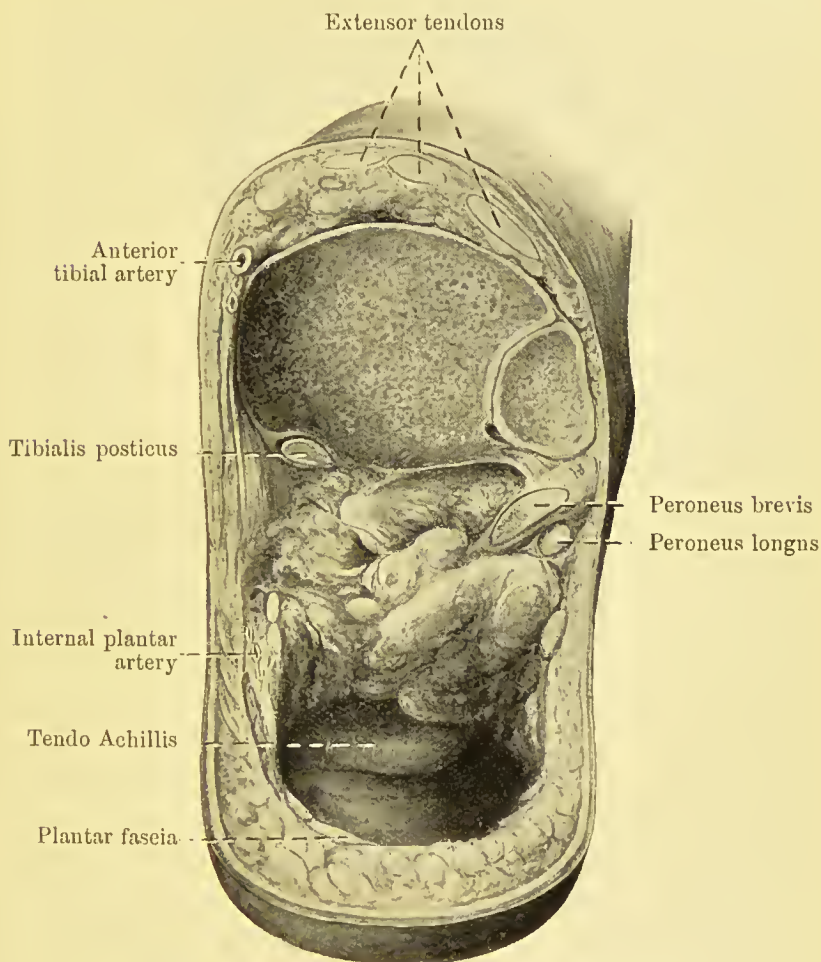


FIG. 106.—Amputation of Left Foot by Syme's Method.

absence of suppuration, the stump is an excellent one.

*Pirogoff's Operation* (1854).—The incisions resemble those employed in Syme's amputation, but are made so as to retain a little more of the soft parts, as there is more bone to be covered. In mapping out the heel flap

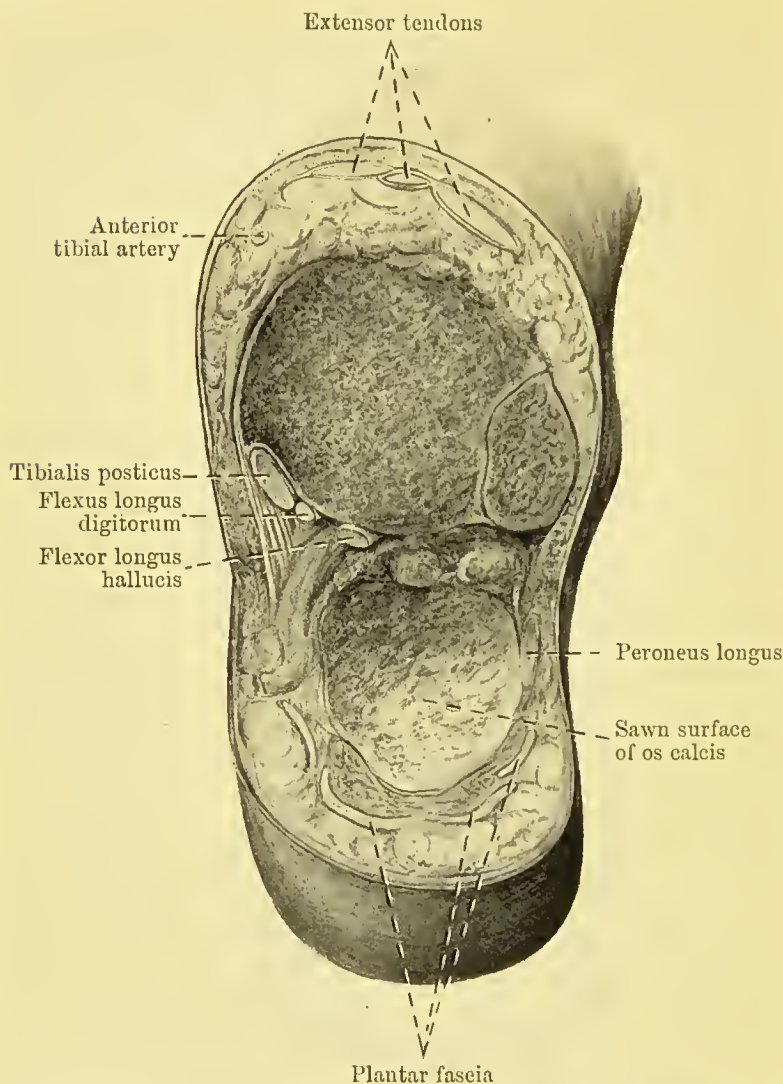


FIG. 107.—Amputation of Left Foot by Pirogoff's Modification of Syme's Method.

the incision begins a little in front of the tip of the external malleolus, and passes slightly forwards before crossing the sole to the corresponding point on the other side; the cut is made right down to the bone, dividing the tendons in its course. The dorsal incision is made convex forwards, and should reach a full thumb's breadth



in front of the line of the ankle joint; it divides the skin and fascia, and then the extensor tendons at the level of the retracted skin. The foot having been forcibly depressed, the dorsal flap is raised and the ankle joint opened; the lateral ligaments which bind the malleoli to the tarsus are divided, and in doing so care must be taken not to cut into the soft parts, especially behind the internal malleolus, in case of wounding the posterior tibial artery. The astragalus is now exposed as far back as its posterior surface until the posterior ligament of the ankle is reached; this is cut close to its insertion into the astragalus, and the knife is able to clear the upper surface of the os calcis. Still holding the foot with the left hand, the operator applies the saw and divides the os calcis in the line of the incision made for the heel flap; the foot is now separated. The malleoli are freed with the knife, care being taken of the posterior tibial artery, the tibia and fibula are cleared to just above the ankle joint, and the lower ends are removed with the saw. The sawn section may be made horizontally, but it is better to incline it downwards as it passes backwards, so as to be as nearly parallel as possible to the section of the os calcis. The sawn surfaces are brought into accurate apposition without tension, and are retained by catgut sutures passed through the periosteum, or by a steel peg driven through the centre of the heel flap so as to pass up through the os calcis into the tibia. If there is tension, the tendo Achillis may be divided subcutaneously. Some surgeons divide the tendon as the first step in the operation.

The advantages of the Pirogoff method are that the stump is a little longer; it is more robust, so that the patient is able to walk upon it at the end of a month; and there is no cavity left in the heel flap in which blood may accumulate (Fig. 107). The operation is best



adapted to cases of injury, and is not to be employed if there is disease in the os calcis. The objection has also been made that the os calcis may not unite to the tibia, but this has little foundation, especially if the



FIG. 108.—Skiagram of Stump 15 Years after Pirogoff's Operation.

bones be fixed together with a peg. To describe Pirogoff's amputation as a "dissecting-room exercise" is to disparage a procedure the value of which we and others have amply demonstrated both in hospital and private practice.

The operation is more difficult than Syme's, and the

beginner is apt to cut the posterior tibial artery in clearing the internal malleolus or to retain so much bone in the heel flap as to cause tension on that vessel when the flap is brought into contact with the tibia; through one or other or both of these faults the heel flap may undergo necrosis.

**Disarticulation at the Ankle-Joint by an Internal Flap.**—When the skin on the outer side of the ankle is not available, on account of an oblique crush of the foot or of sinuses, a flap may be marked out from the inner side (Richard Mackenzie, 1849). With the foot and ankle projecting from the table with their internal aspect upwards, the point of the knife is entered in the mesial line of the posterior aspect of the ankle, on a level with the articulation, carried down obliquely across the tendo Achillis towards the external border of the plantar aspect of the heel, along which it is continued in a semilunar direction. The incision is then curved across the sole of the foot, and terminates on the inner side of the tendon of the tibialis anticus, about an inch in front of the inner malleolus. The second incision is semilunar and is carried across the outer aspect of the ankle between the extremities of the first incisions, the convexity of the incision being downwards, and passing half an inch below the external malleolus.

The internal flap may be dissected up in the first instance, or the joint may be opened first on the outer aspect. After the external lateral ligament, the peroneal tendons, and the extensor tendons have been divided, the inner aspect of the os calcis is finally dissected from above downwards from the internal flap.

Tauber's modification is to saw through the os calcis in the sagittal plane and retain the inner half in the main flap, which is brought into contact with the sawn section of the bones of the leg.

When the skin on the inner aspect of the foot, as well as the heel, is not available, a flap may be formed from the outer side on the same principle as in Mackenzie's amputation, but the blood supply of the external flap is more precarious.

**Amputations through the Leg.**—In pre-antiseptic days, when the majority of operation wounds suppurated, it was found that in amputations performed between the ankle and the tubercle of the tibia the stump was generally unable to bear sufficient pressure to support the weight put upon the limb, and the patient had to rest the anterior surface of the flexed knee on an artificial leg, the stump projecting behind in the manner depicted in the traditional picture of the Chelsea pensioner. To avoid the inconvenience of a long projecting stump it became the practice, when the limb had to be removed above the level of the ankle, to amputate about a hand's breadth below the knee, leaving just enough of the upper ends of the tibia and fibula to admit of the patient resting on the front of the bent knee. This was known as amputation at the "seat of election" — a term which has now lost its significance.

Under aseptic conditions a good stump can be obtained at any level in the leg.

**Methods.**—The covering for the bones may be formed of two unequal flaps, the longer being cut from the extensor aspect of the limb and the shorter from the flexor aspect; or this proportion may be reversed. So long as the soft parts furnish a covering for the bones without tension, and the scar does not fall directly opposite the end of the stump, no fixed proportion between the length of the two flaps need be adhered to. A convenient guide, however, is that the length of the long flap should be equal to at least a diameter of the limb at the level of bone section, and the short flap about

half the length of the long one. The method devised by Teale of forming an extensor flap equal in length and breadth to half the circumference of the limb at the level of bone section, and a flexor flap one-quarter of the length of this, is seldom practised now, as it involves sacrificing more of the limb than is necessary.

The elliptical method is universally applicable; in marking it out the flap should be equal to one and a half times the diameter of the limb at the level of bone section.

In making the incision the skin and fat are first divided and allowed to retract, and at the level to which they have retracted the muscles are cut by circular sweeps of the knife. Before sawing the bones the interosseous membrane should be cleared, the knife being held at right angles to the long axis of the limb to prevent the vessels being slit longitudinally.

If the tibia is sawn straight across the sharp anterior edge is apt to press unduly on the part of the flap resting against it, and to obviate this the anterior surface of the tibia should be bevelled, by entering the saw obliquely, a little above where it is intended to divide the bone, and, after cutting for a short distance, withdrawing the saw and reapplying it at right angles about half an inch lower down.

Before the bones are divided the assistant should rotate the leg inwards so as to bring the fibula forwards and enable the saw to be applied to both bones at once, and if it is desired to divide the fibula at a higher level than the tibia, as is usually done, the fibula should be sawn across first.

**Osteoplastic Amputations through the Leg.** — The method by elliptical incision should be supplemented whenever possible by the retention of a portion of the tibia along with the soft parts forming the flap, such

portion being applied against the tibia after it has been sawn across at a higher level (Bier).

The skin and fat having been divided by an elliptical incision so arranged that the covering is taken from the antero-external aspect of the limb (Kocher), the muscles are divided at the level of the retracted skin and allowed

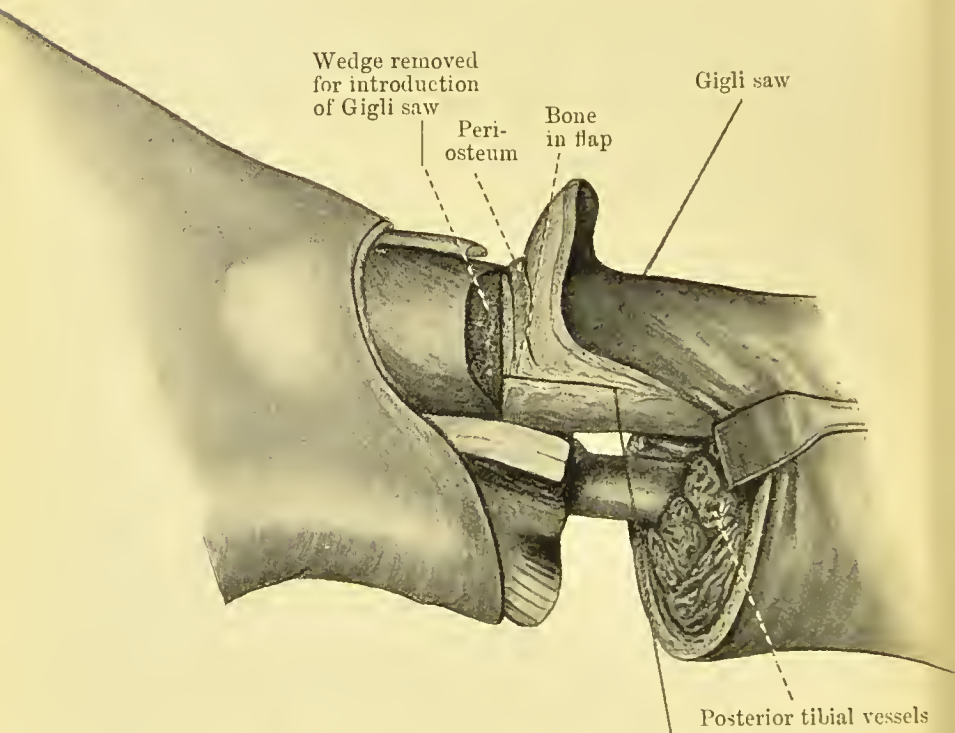


FIG. 109.—Osteoplastic Amputation of Leg, 1st stage.

to retract, but care is taken not to separate the integument from the subcutaneous surface of the tibia. An incision is then made through the periosteum of the tibia, mapping out a flap of bone sufficient to cover the ends of the tibia and fibula when they have been divided. This bone flap is cut with a Gigli saw (Figs. 109, 110) or with a chisel and mallet, and reflected with the periosteum and integument in one piece. The bones



are then sawn across at a level slightly above that of the retracted muscles, and the osteo-cutaneous flap brought over the face of the stump. Care must be taken that the

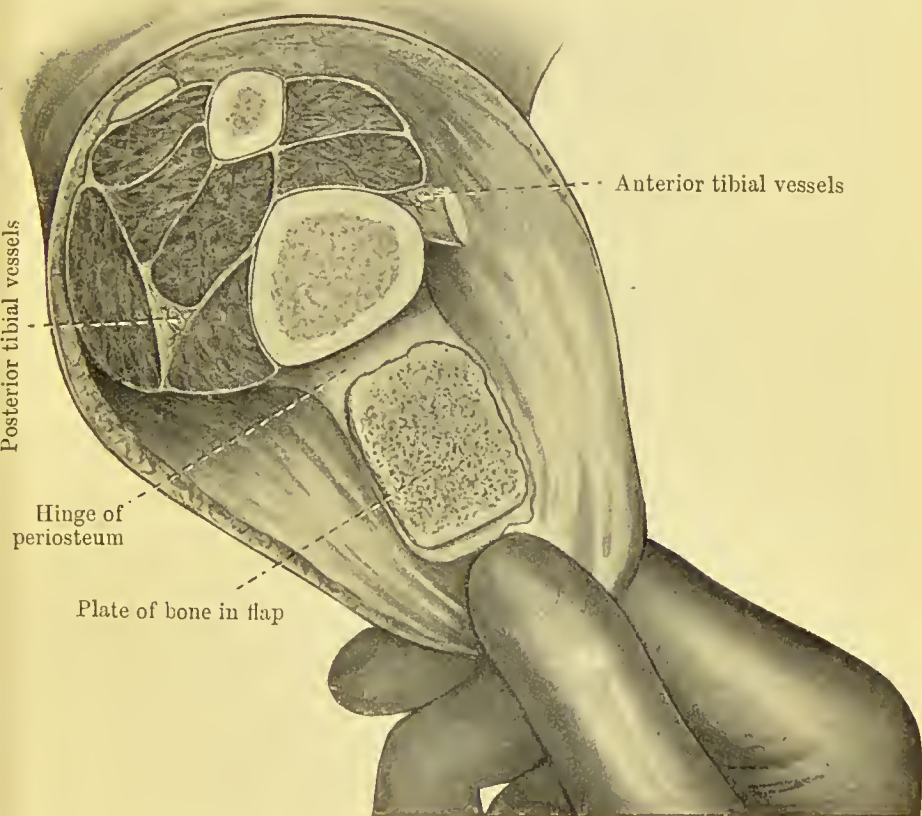


FIG. 110.—Osteoplastic Amputation of Leg, 2nd stage.

fresh bone surfaces lie in accurate contact; they may be secured by catgut sutures, or if necessary by a peg driven through the overlying skin. Kocher attempts to adapt the surfaces to one another by making the sawn surface of the tibia concave and that of the bone flap convex. If the fibula is sawn at a higher level than the

tibia the bone flap is applied to the tibia only (Fig. 111). Cutting the bone flap with the chisel is apt to cause longitudinal splintering.

Haffter recommends that a portion of the fibula should be used to cover the end of the tibia. He cuts



FIG. 111.—X-ray Photograph of Stump after Osteoplastic Amputation.

the skin ellipse so that the covering for the bones is taken from the outer aspect of the limb. The tibia is divided higher than the fibula, and from the latter he takes a wedge with its base towards the tibia, and brings the flap containing this piece of bone over the sawn surface of the tibia.

Throughout the greater part of the leg the anterior tibial vessels are found on the interosseous membrane, the posterior tibial vessels between the superficial and deep muscles of the calf, and the peroneal vessels in the lower two-thirds of the leg immediately behind the fibula. Any nerve trunk in the long flap should be dissected out and divided above the level of the weight-bearing part.

**Amputations in the Upper Third of the Leg.**—Farabœuf's method by antero-external flap may be employed. The incision commences in front opposite the level of bone section—a hand's breadth below the knee-joint—and runs down parallel with and close to the inner border of the shin. It crosses the outer aspect of the limb and runs up posteriorly in the middle line, and terminates one and a half inches lower than where the incision commenced in front; the length of this U-shaped flap should be equal to a diameter of the limb at the saw line. On the inner side the incision is made straight across from the upper end of the posterior limb of the U to meet the anterior limb one and a half inches below its upper end. The long anterior flap should contain everything down to the bone, and the anterior tibial artery is divided at the end of the flap. The scar lies to the inner side.

## CHAPTER XIV

### AMPUTATIONS OF LOWER EXTREMITY (Continued)

AMPUTATIONS IN REGION OF KNEE. DISARTICULATION AT KNEE: *A. G. Miller's method; Other methods.* AMPUTATIONS THROUGH AND ABOVE CONDYLES OF FEMUR: *Carden's; Gritti's; Stokes'; Other methods.* AMPUTATIONS THROUGH THIGH: *Spence's.* AMPUTATIONS IN REGION OF HIP: *Racket method; Furneaux-Jordan's.* INTER-ILIO-ABDOMINAL AMPUTATION.

#### AMPUTATIONS IN THE REGION OF THE KNEE

IN amputating in this region it is to be borne in mind that, as there is very little muscle in front of the femur, the anterior flap retracts but slightly after division, while the hamstring muscles in the posterior flap, being divided at some distance from their attachment, retract much more. To allow for this the posterior muscles should be cut as low as possible. As the blood supply of the anterior flap depends to a large extent on the integrity of the pre-patellar anastomosis, the patella should, if possible, be retained in the flap so as to avoid disturbing the vessels between it and the skin.

Whether the limb is removed by disarticulating at the knee joint or by dividing the femur depends on the nature of the lesion and the skin available to form the flaps.

Many cases of senile gangrene, of gun-shot wounds

shattering the bones but not destroying the skin widely, and malignant growths in the bones of the leg, may be dealt with by disarticulation. For tuberculous or other disease causing disorganisation of the joint it is necessary to divide the femur either through or above the condyles.

**Disarticulation at the Knee-Joint.**—The advantages claimed for this operation over those performed a little higher up are that it furnishes a longer stump, which is more completely under the control of the adductor muscles, as the round tendon of the adductor magnus is retained; and that the end of the stump, being broader and more rounded, is better adapted to bear the weight of the body. On the other hand, the stump does not lend itself so well to the fitting of an artificial limb with a movable knee-joint, as the false articulation falls below the level of the normal one. Disarticulation at the knee-joint is best performed by the *circular method of A. G. Miller*. The limb is held fully extended, and the skin and fat are divided about three inches below the joint and raised from the deeper parts in the form of a cuff; when the ligamentum patellæ is exposed it is cut across and the joint is flexed; the knife is then inserted between the semilunar cartilage and the tibia, dividing the capsular and coronary ligaments and the synovial membrane, first on one side and then on the other. The joint is now flexed to a right angle, and the lateral and crucial ligaments are divided, which allows the tibia to be drawn away from the femur. The fingers of the left hand grasping the structures in the ham compress the popliteal vessels, and the severance of the posterior soft parts is completed by one sweep of the knife. The vessels—the popliteal and the articular branches—are secured, the tibial nerves are pulled out and cut short, and, a drain having been inserted through a separate opening, the skin and fat are sutured in the



horizontal plane. The wound lies behind the condyles of the femur, and the scar is ultimately situated above and behind the condyles owing to the marked retraction of the hamstring muscles. The patella is retained in the anterior flap, and comes to lie in the hollow between the condyles of the femur.

The stump is an excellent one.

Among the other methods may be mentioned that of *Stephen Smith* by *lateral flaps*, in which, owing to the great prominence and size of the internal condyle, the inner flap is cut a little fuller than the outer one. In the *elliptical method* the lowest point of the ellipse falls on the anterior surface of the leg a full hand's breadth below the level of the joint.

**Amputations through and above the Condyles of the Femur.**—It is usual to employ a tourniquet in these amputations, and it should be applied high up in the thigh, so as not to interfere with the mobility of the skin and the retraction of the muscles after division. The mode of dealing with the patella, and the level at which the femur is sawn across, vary with the method employed.

*When the patella can be retained* the operation is performed by taking a long flap from the front of the joint, and a shorter one from the posterior aspect. With the knee extended the knife is entered over the most prominent part of one condyle, and carried almost vertically downwards to the level of the attachment of the ligamentum patellæ; it then passes across the front of the limb, and up again to the most prominent part of the opposite condyle. The knee is then flexed and the patellar ligament cut across, thus opening into the knee-joint. The soft tissues, including the capsular ligament of the joint, are freely divided down to the bone. A posterior flap, about half the length of the anterior one, is then formed by one stroke of the knife

dividing the integument, and a second severing the hamstring muscles at the level of the retracted skin. The saw is now applied and the bone divided through the upper part of the condyles.

The popliteal and articular vessels having been secured and the nerves cut short, the articular surface of the patella is removed with the saw and applied to the raw



FIG. 112.—Incisions for Gritti-Stokes Supra-condylar Amputation.

surface of the femur. This adaptation of the osteoplastic method was suggested by Gritti in 1857. To permit of the patella being brought against the femur without tension, and to adapt the size and shape of the divided surface of the femur to that of the patella, Stokes recommended that the bone should be sawn across from half to three-quarters of an inch above the condyles. This *supra-condylar amputation* is known as the *Gritti-Stokes method*.

If the end of the femur is made convex and the patellar surface concave, and if the patellar

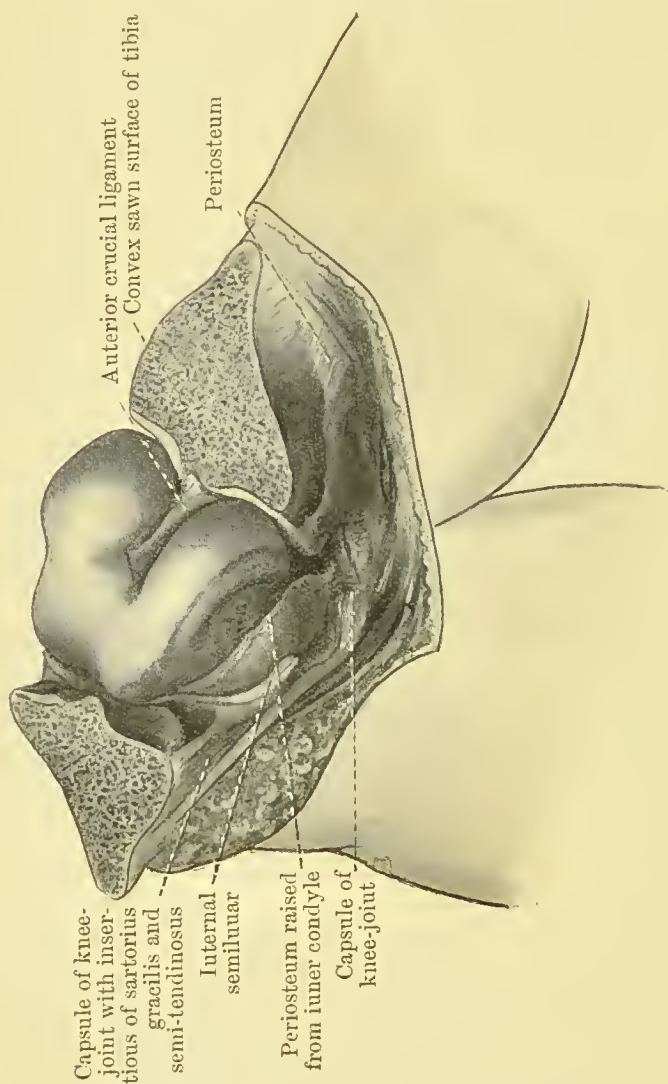


FIG. 113.—Amputation through the Condyles of the Femur by the Osteoplastic Method of Ssabanejef.

ligament is cut so that it can be stitched to the periosteum on the back of the femur and to the hamstring muscles, the stump is made more compact (Kocher).

If there is any tendency for the patella to become displaced from the femur, it may be held in position by a steel pin inserted through the skin after the flaps have been sutured. The pin is removed in two or three weeks. As soon as the wound is consolidated massage of the limb is commenced, and the patient is usually able to bear his full weight on the stump at the end of a month.

Ssabanejeff has suggested another osteoplastic procedure, suitable to cases in which the upper end of the tibia and the knee-joint are free of disease. A pyramidal portion of the tibia is retained in the anterior flap, which must be carried to a point three fingers' breadth below the tubercle, and this is applied to the sawn surface of the condyles of the femur (Fig. 113). The advantages claimed for this method are that the skin, bursa, and bone in the anterior flap are accustomed to bear pressure, and the tendinous insertions of the sartorius and gracilis, and also part of the biceps expansion, are retained.

*When the patella must be sacrificed* one of the modifications of *Carden's operation* is employed.

Carden's original operation, described in 1864, consisted in raising a flap of skin from the front of the joint as far down as the middle of the ligamentum patellæ, dividing everything else straight down to the bone at the level of the base of this flap, and sawing across the condyles of the femur.

To avoid relying on a single long skin flap, which was found to be liable to slough, Lister (1883) recommended division of the skin and fat on the anterior aspect at the level of the tubercle of the tibia, and on the posterior aspect at a slightly lower level, the muscles being divided at the level of the retracted skin and the bone sawn through the condyles.

The posterior flap was still further developed in a modi-

fication devised by John Chiene (Fig. 114). An anterior flap is formed as in Carden's operation, and a posterior flap mapped out, by carrying downwards on each side from the upper end of the anterior incision a vertical incision in the long axis of the limb, reaching as far as the lower limit of the tuberosities of the tibia,

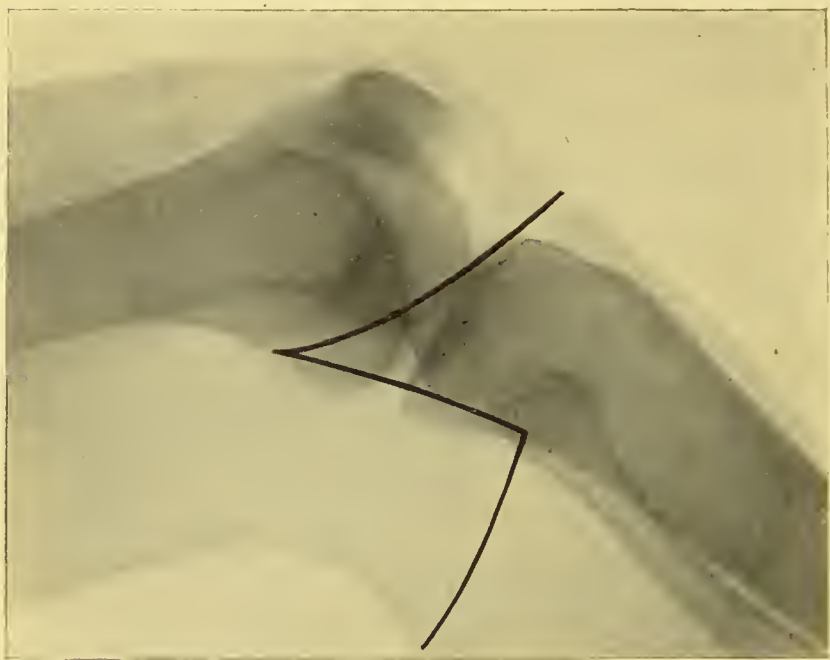


FIG. 114.—Incisions Employed in Chiene's Modification of Carden's Amputation.

and joined across the back of the leg. The muscles on the posterior surface are then cut transversely. The flaps thus formed are retracted sufficiently to expose the femur at the highest part of the articular surface, where the saw is applied.

Instead of the bone being sawn straight across it is better to saw it in a curve parallel to the articular surface (Fig. 114).

In performing these operations and those a little higher



in the thigh, the surgeon has a choice of methods. He may hold the limb himself with his left hand while he outlines the flaps (Fig. 115) and has them raised for him by an assistant, or, the leg being held for him, he employs his left hand to raise and retract the flaps. The former is the more showy and brilliant; it was greatly favoured by Annandale, who, after marking

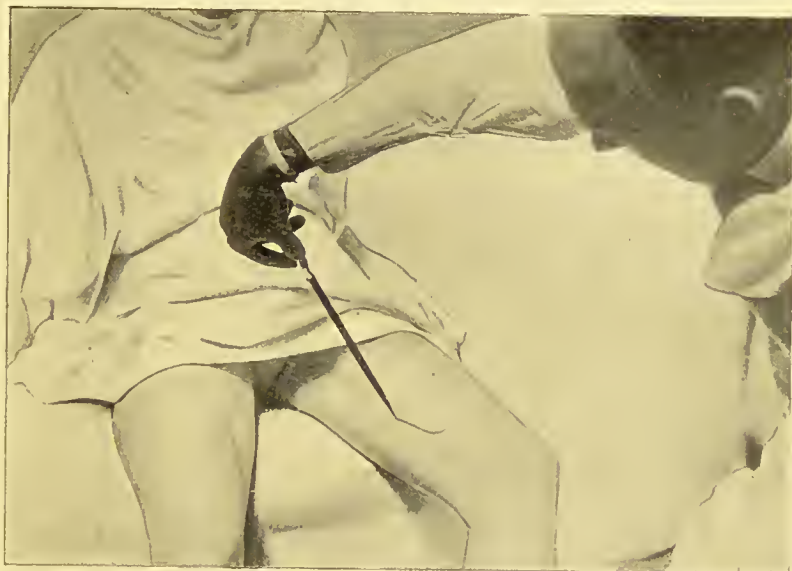


FIG. 115.—One Method of Cutting Anterior Flap in Amputation through the Thigh.

(The surgeon is holding and rotating the limb with his left hand; the track of the knife is indicated by a faint line.)

out and having raised for him the anterior flap, used then to saw the bone and, passing the knife in between the sawn surfaces, cut the posterior flap by transfixion.

**Amputations through the Thigh.**—In the thigh several different methods of providing a covering for the bone are available, the circular or the elliptical incisions, or the formation of anterior and posterior flaps being the most generally applicable. In making a

choice it must be borne in mind that the masses of muscle on the different aspects of the limb do not retract equally when divided, and allowance should be made for this to ensure that the stump is well formed. The extensor and adductor groups, for example, owing to the pennate form of their fibres, their intimate attachment to bone, and the manner in which they are bound to one another, retract much less than the hamstring group, which run independently, have purely longitudinal fibres, and are divided at a considerable distance from their attachments of origin.

When the muscles are relaxed under anæsthesia, and the limb is raised preparatory to making the incisions, under the influence of gravity an undue proportion of the bulk of the limb sags towards the posterior aspect, and unless this is controlled by the assistant supporting the tissues behind the bone on the palm of his hand while the surgeon plans his incisions, the covering for the bone is apt to be unequally distributed, with too much on the posterior aspect.

It is further to be borne in mind that the position of the main blood vessels varies at different levels in the thigh; in the lower third they are towards the back of the limb, in the middle third towards the inner aspect, and in the upper third more towards the front. In amputating by transfixion in the middle third of the thigh there is a danger of slitting the vessels longitudinally.

**Amputation through Middle or Lower Third of Thigh by long Extensor and short Flexor Flaps.**—From opposite the point at which the bone is to be divided an incision is carried down one lateral aspect of the limb, across the front of the thigh, and up along the opposite aspect, mapping out a U-shaped flap equal in length and breadth to the diameter of the limb at the level of bone section. The posterior flap, about half the length

of the anterior one, is delimited by carrying the knife straight, or with a slight downward curve, across the back of the thigh from one lateral incision to the other. The muscles are then divided at the level to which the skin has retracted, and, to avoid having an excess of muscle in the flaps and to ensure their more accurate apposition, the section should be oblique, so that there is most muscle towards the base of each flap. It should be arranged that the main vessels fall into the posterior flap. The bone is then cleared and sawn across, and the sharp edges rounded off.

The femoral vessels, which lie beneath and to the outer side of the sartorius, are secured and ligated, and the larger branches of the profunda, gluteal, obturator, and sciatic arteries found in the inter-muscular septa are similarly dealt with. The sciatic nerve is sought for among the hamstring muscles and cut short, the comes nervi ischiadici artery which accompanies it being secured. To obliterate dead spaces, to diminish subsequent oozing, and to prevent undue retraction, the muscles of the two flaps should be stitched with catgut.

After this amputation the weight is only partly borne on the face of the stump, the artificial limb being so arranged that the weight is distributed as in Thomas' knee splint.

The *circular* and *elliptical* methods differ from the above only in the manner of dividing the skin. The unequal retraction of muscles in the two aspects of the limb results in the formation of two unequal flaps.

**Amputations in the Region of the Hip.**—It is convenient to describe together the operations in which the femur is divided in the region of the trochanters, and those in which disarticulation is performed at the hip-joint, as the general technique of the procedures is similar.

In planning the operation it is to be kept in mind that the stump is not designed to bear pressure, as the

weight of the body is transmitted to an artificial limb through the bones of the pelvis in much the same way as by a Thomas' knee splint. At the same time it is desirable to retain in the stump sufficient muscular tissue with bony attachment to render the stump movable in all directions, as this facilitates the adjustment of a well-fitting artificial limb, and adds materially to the patient's control over it in locomotion. This implies that the section of the limb should be made as low down as possible consistent with removing all disease and securing a satisfactory covering.

Hæmorrhage and shock are the immediate risks of the operation. The most effective means of controlling the bleeding is by ligating the common femoral or external iliac vessels as the first step of the operation; if the external iliac has been ligated the branches of the gluteal, sciatic, obturator, and external circumflex vessels are secured with forceps as they are cut. When this plan is not adopted, one or other of the methods of controlling bleeding by pressure or by a tourniquet may be selected (vol. i. p. 278). The abdominal aorta may be compressed against the bodies of the lumbar vertebrae with the closed fist (Maccwen), or by an elastic cord wound round the body between the iliac crest and the lower border of the ribs (Momburg). An elastic tourniquet applied round the root of the thigh encroaches upon the field of operation, and is liable to slip downwards after the incisions have been made. This latter accident may be prevented by using Spence's skewer—a long flat steel pin—which is made to transfix the limb in front of the femur about the level of the great trochanter, and over its projecting ends one piece of elastic tubing is wound as a figure-of-eight across the front of the thigh, and another over the back. In this way the vessels are constricted and the tourniquet is prevented from slipping, and after the limb is removed the vessels can be secured with forceps

before the elastic constrictors are removed and the skewer withdrawn. Wyeth achieves the same object by transfixing the limb from before backwards with two pins, one passed on each side of the femur, and applying an elastic tourniquet above the pins.

Whatever method is employed the lower end of the table should be raised to favour the flow of blood from the lower limbs into the great veins.

The usual precautions against shock are taken, and in addition it has been found advantageous to "block" the large nerve trunks—anterior crural and sciatic—by injecting a solution of novocain into them before they are divided.

**Amputation by the Anterior Racket Method, with Preliminary Ligation of the Femoral Vessels.**—This operation, associated with the names of Beck and Rose, is in our opinion the method of choice, and it is more widely applicable than any other. It can be performed with the minimum loss of blood, it permits either of high division of the femur or of disarticulation as may be found necessary, and it can be performed with a single assistant.

The racket-shaped incision is commenced over the line of the femoral vessels, which it exposes for a length of several inches; it then crosses the thigh obliquely, passing over the adductor muscles four or five inches below the genito-femoral fold, thence across the back of the thigh and over its outer aspect till it again meets the vertical incision. The skin thus mapped out is allowed to retract.

The femoral artery and vein are separately secured with double ligatures and then cut across (Fig. 116); and the anterior crural nerve is "blocked" by an injection of novocain before being cut.

If it is intended to *saw across the femur*, the muscles are divided at the level of the retracted skin by a few



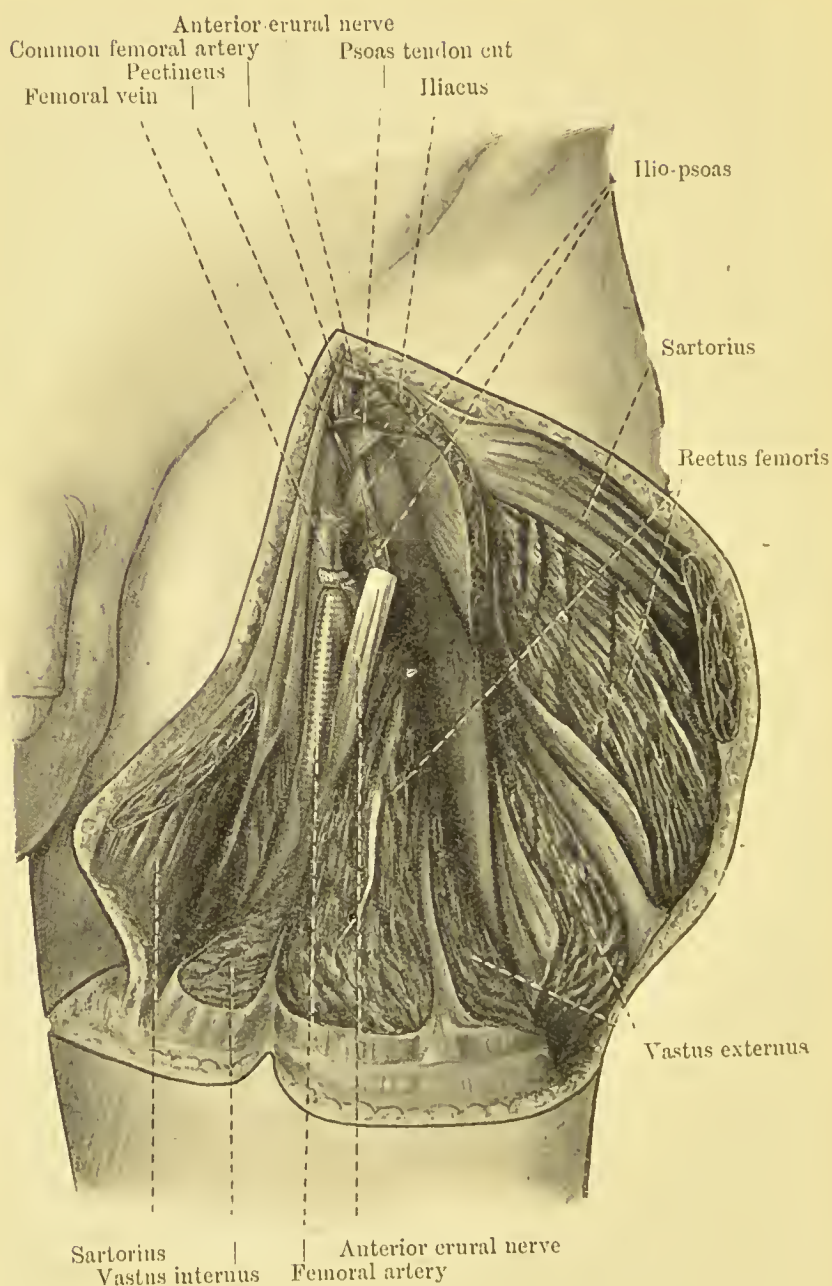


FIG. 116.—Amputation in upper part of Thigh by Anterior Racket Method.

circular sweeps of a long-bladed knife, the bone exposed, and the saw applied at the desired level.

If *disarticulation* is to be performed, after cutting the skin in racket fashion, the sartorius, the ilio-psoas, and the other muscles in front of the thigh are divided and the capsule of the joint opened from the front. The remaining muscles are divided one after the other, and the blood vessels secured as they are cut, and the great sciatic nerve injected with novocain before it is divided. Disarticulation is facilitated if the assistant puts the structures to be divided on the stretch.

The muscular masses are brought together by catgut sutures, and the wound closed, drainage being provided for at its outer and lower angle.

The skin wound, which takes the shape of an inverted T, looks towards the outer aspect of the limb, where it is less liable to infection from the perineum.

**Amputation by an External Racket Incision — Furneaux-Jordan's Operation.**—The principle of shelling out the upper end of the femur through an incision carried along the outer aspect of the femur, and dividing the muscles by a circular incision round the thigh, associated with the name of Furneaux-Jordan, is applied in different ways.

The method we have usually adopted is as follows. The limb is emptied of blood and a tourniquet applied round the root of the limb. A circular incision is then made as low down in the thigh as is practicable. After the skin has retracted, the muscles and other soft parts are divided by a few circular sweeps of the knife, the bone is sawn across, and the limb removed. The vessels are picked up with forceps and ligated before the tourniquet is relaxed. The patient is then placed on his sound side and a vertical incision is made on the outer aspect, passing over the middle of the great trochanter to end midway between the tip of the trochanter and

the iliac crest. The vertical incision is deepened and the tissues, including the periosteum, as far as possible peeled off the bone. When the region of the joint is reached a short strong-bladed knife, such as Syme's, is used to disarticulate, the muscles attached to the trochanters and the capsule being in turn put upon the stretch by an assistant manipulating the limb. The disarticulation is most speedily accomplished by entering

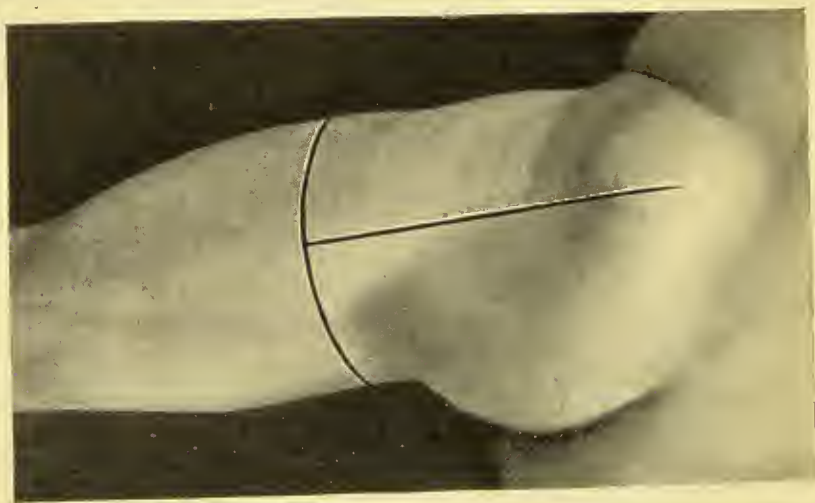


FIG. 117.—Incision for Furneaux-Jordan's Amputation.

the joint from the front, and, after dividing the cotyloid ligament, forcing the head of the bone from the acetabulum by depressing the limb and rotating it outwards. The round ligament is thus brought within reach and is divided, after which the head is easily withdrawn from the socket and the posterior part of the capsule divided.

After the bleeding has been stopped, the large muscular masses are brought into apposition by catgut stitch, and the skin sutured, drainage being provided for at the outer aspect of the wound.

If the periosteum has been saved a certain amount of bone is eventually developed from it, and this adds to the functional value of the stump, by conferring on it a moderate range of movement.

**Amputation of the Lower Extremity and Part of Pelvis—Inter-ilio-abdominal Amputation.**—This operation was first performed by Billroth in 1889 for sarcoma of the pelvis. Undue loss of blood is prevented by preliminary ligation or clamping of the common iliac vessels. An incision is made parallel with Poupart's ligament and three fingers' breadths above it, the aponeuroses of the external oblique and the internal oblique and transversalis muscles are divided, and the transversalis fascia and peritoneum are raised from the iliac fossa until the common iliac vessels are exposed. The artery is clamped or ligated, and the limb, having been raised to the vertical position so as to empty it of blood, the vein is also occluded. The inner aspect of the pelvis is now explored by the fingers to determine the extent of the disease, and the site at which the innominate bone is to be divided (Kocher).

To expose the posterior aspect of the bone, an incision is made like that for exposing the gluteal artery, that is, from the posterior iliac spine downwards and outwards in the direction of the fibres of the gluteus maximus. The fibres of the gluteus maximus are separated and drawn aside with hooks, and the gluteal artery secured at its emergence from the notch. The upper margin of the notch is defined and the site of division of the bone determined upon. The tendon of the pyriformis is divided, the sciatic nerves exposed, the great one injected with novocain, and both cut across. The spine of the ischium is chiselled through at its base, well outside the pudic vessels and nerve. The obturator internus with the two gemelli is displaced downwards, exposing the great sciatic ligament, and the



ischium is divided with the chisel a little above the tuberosity.

The existing anterior and posterior incisions are now joined, the gluteus maximus and medius muscles are divided, if thought advisable between clamps, in the line in which it is proposed to divide the ilium. The lateral abdominal muscles are then divided above the crest of the ilium, again between clamps, until the crest is cleared up to the point where it is to be divided. The external iliac vessels, with the ilio-inguinal and genito-crural nerves, are raised from the inner border of the psoas, while the anterior crural and external cutaneous nerves running downwards upon the psoas and iliacus are divided. The ilio-psoas is cut across high up, and the ilium is now divided right down to the sciatic notch with a broad chisel or a Gigli saw.

An anterior incision outlining the inner flap over the adductors is now made, and by dividing these muscles access is obtained to the femoral vessels and to the pubis. The vessels are ligated above the origin of the profunda, the horizontal ramus of the pubis is divided with the chisel, and the obturator muscles cut across. The pelvis can now be drawn downwards and outwards, for it is only held by the levator ani and pelvic fascia; the latter is divided at the entrance to the true pelvis, care being taken to preserve the obturator nerve and vessels and the band of fascia to which the levator ani and coccygeus muscles are attached.

The posterior and outer parts of the incision are completed, the hamstrings cut across and any bleeding vessels secured. The clamps compressing the muscles are now removed seriatim and the vessels ligated; the temporary clamp or ligature on the common iliac artery is removed, and the obturator, circumflex,



and gluteal arteries, which now bleed, are seized and tied.

The flaps afford sufficient covering if the entire innominate bone is removed at the saero-iliac joint. If, however, the ilium is sawn through, more covering is required, and the flaps must be made a little fuller.

## CHAPTER XV

### AMPUTATIONS OF THE UPPER EXTREMITY

AMPUTATIONS OF FINGERS AND THUMB. DISARTICULATION AT METACARPO-PHALANGEAL JOINT. REMOVAL OF FINGER OR THUMB WITH METACARPAL. DISARTICULATION AT WRIST: *Methods.* AMPUTATIONS THROUGH FOREARM: *Lower third; Upper third.* DISARTICULATION AT THE ELBOW: *Methods.* AMPUTATIONS THROUGH UPPER ARM: *Methods.* DISARTICULATION AT SHOULDER-JOINT: *Spence's method; Furneaux-Jordan's method; Other methods.* INTERSCAPULO-THORACIC AMPUTATION: *Berger's method.*

THE first consideration in planning an amputation in the upper extremity is to save as much of the limb as is consistent with removal of the diseased or grossly damaged tissue, and to conserve as far as possible the movements of the parts retained.

The weight or pressure-bearing capacity of the stump being of secondary importance, it is as a rule immaterial whether or not the scar falls opposite the end of the bone.

When the operation is being performed *for disease*, such as tuberculosis of a joint or a malignant growth, it is necessary to amputate through healthy tissue at some distance above the diseased area, and a satisfactory covering for the bones can best be secured by selecting from among the typical operations to be subsequently described the one which involves least sacrifice of tissue.

In amputating *for injury*, on the other hand, set operations should be avoided, and the coverings secured wherever they can be got, the primary considerations

being to save as much of the limb as possible, and to secure asepsis in the wound.

In any case, if infection is prevented, the position of the scar in relation to the end of the bone may be disregarded.

**Amputations of the Fingers and Thumb.** — The smallest portion of a finger that can be saved is of value to the patient, particularly if it is movable and is capable of being opposed to the thumb.

In dealing with the *thumb* it is even more important to save tissue, with the object of furnishing something against which the other fingers or stumps can be opposed. Formal amputations must as far as possible give place to mere trimming of the soft parts, such bone as must be sacrificed being shelled out of its investing periosteum.

Hence the importance of amputating through the phalanges when this is possible, rather than of disarticulating, so that the attachments of the tendons may not be disturbed. The attachment of the flexor profundus tendon is preserved by retaining the base of the terminal phalanx, and that of the flexor sublimis by retaining the base of the second phalanx. It is to be borne in mind that the prominence of the finger joints is formed by the distal end of the proximal bone entering into the formation of the joint, hence the joint always lies distal to the "knuckle."

If the divided ends of the flexor and extensor tendons are stitched to one another over the end of the bone, the patient obtains control of the movements of the stump. To enable this to be done the tendons must be cut as long as possible, and the finger should be semi-flexed while they are being divided so that they may be as nearly equal as possible. In stitching the tendons it is desirable to close their sheaths so that, should infection occur, its extension by way of the sheath may be prevented.

When possible the cicatrix should fall towards the dorsal aspect, as this is the part of the finger which is least subjected to pressure.

*Amputation through the Terminal Phalanx.*—It has already been indicated that if possible the base of the terminal phalanx should be retained, because when disarticulation is performed at the inter-phalangeal joint the attachment of the deep flexor tendon is necessarily



FIG. 118.—Incisions for Amputations of Fingers.

sacrificed. A semilunar incision is made on the dorsal aspect, dividing the skin and the extensor tendon, and after snipping across the bone or disarticulating, as the case may be, a rectangular flap is formed from the palmar aspect by cutting from within outwards.

An *elliptical incision*, the higher end of the ellipse being on the dorsum, is equally satisfactory.

*Amputation of the two Distal Phalanges of the Fingers.*—

An attempt should always be made to save the attachment of the flexor sublimis tendon by dividing the second phalanx beyond its base. If this is not practicable, disarticulation at the first inter-phalangeal joint must be performed or the proximal phalanx divided.

The most economical method is by cutting *palmar and dorsal flaps*, and, to ensure that the scar will fall just below the dorsal edge of the bone, the palmar flap should be the longer of the two. The flexor and extensor tendons are sutured across the face of the bone and their sheaths closed.

The operation may also be performed by *lateral flaps*, or by a single long palmar flap; or an elliptical incision may be made.

**Disarticulation at the Metacarpo-phalangeal Joint.**—

The method of performing this operation will vary according to whether the chief consideration is to retain the maximum of grasping power in the hand, or to avoid disfigurement and leave as shapely a hand as possible.

The minimum amount of disfigurement follows the use of a *racket-shaped incision*. With his left hand the surgeon grasps the digit to be removed, while an assistant holds aside the adjacent fingers by means of pieces of moist gauze wrapped round them. The incision, which is carried down to the bone, commences on the dorsum immediately above the centre of the joint (Fig. 118), and is carried round the root of the finger at the level of the free margin of the web. The joint is most easily opened from the palmar aspect, and the glenoid ligament is best divided by cutting against the base of the proximal phalanx. In the middle and ring fingers it is usual to retain the head of the metacarpal bone, and sufficient covering must be provided for it, but if a neat hand is of more importance to the patient than a strong one the head of the bone should be removed. This allows of



the adjacent fingers falling together and renders the gap less conspicuous. In the index and little fingers the appearance of the hand is improved by cutting the head of the metacarpal bone obliquely with bone-pliers, and to give the necessary access for this, the handle of the ratchet should commence over the neck of the bone (Fig 118). The sear is less noticeable also; although more exposed to pressure, if the handle of the ratchet is placed towards the free border of the hand.

In patients engaged in hard manual labour who require a broad hand with good grasping power, the method of amputating by a *palmar flap*, recommended by John Chiene, is to be preferred. The knife is entered over the prominence of the knuckle and inclines downwards to the middle of the lateral aspect of the root of the finger, first on one side and then on the other (Fig. 118). A palmar flap extending to near the first inter-phalangeal joint is then formed and reflected, and the joint is disarticulated. The rectangular flap does not at first fit accurately into the V-shaped gap on the dorsum, but the ultimate appearance is quite good, as in time the redundant tissue shrinks and there is no tendency to transverse contraction of the palm.

In the thumb it is most desirable to save the base of the proximal phalanx, as to it are attached the tendons of the extensor brevis, the abductor, the adductor, and the flexor brevis pollicis muscles, and the preservation of these attachments adds greatly to the usefulness of the hand. The mobility of the stump is still further increased by accurately stitching the tendons over the end of the bone. No portion of the thumb should be sacrificed for the sake of leaving a more shapely stump.

In operating by the ratchet-shaped incision the handle is placed in the middle line of the dorsum, and as the head of the first metacarpal is much larger than that

of the others the covering provided for the end of the stump must be proportionately more generous. In planning a palmar flap by Farabœuf's method, the incision must be carried forwards nearly to the base of the distal phalanx.

**Removal of a Finger or Thumb with its Metacarpal Bone.**—This operation is seldom performed except in the case of the little finger, where the removal of the metacarpal adds to the neatness of the hand without appreciably diminishing its usefulness. The racket method is usually suitable, the handle being placed over the dorsum of the metacarpal bone and the "blade" encircling the digit at the level of the free margin of the web. In the outlying fingers the handle of the racket should be placed well away from the free edge of the hand, so that the scar will not be subjected to pressure. As far as possible, the bone should be removed subperiosteally.

**Disarticulation at the Wrist.**—This operation is to be preferred to amputation through the bones of the forearm, as it preserves the inferior radio-ulnar joint and the attachments of the pronator and supinator muscles. The stump being longer, and the movements of pronation and supination being retained, any artificial substitute for the hand that may be applied is rendered more useful.

Several methods of operating are available, and the selection must be made to meet the requirements in different cases.

*The Circular Method.*—Grasping the part to be removed in his left hand, the surgeon makes an incision through the skin and fascia circularly round the hand about an inch and a half below the level of the radial styloid. A cuff of skin is then raised with a few touches of the knife until the level of the styloids is reached. By putting one or other lateral ligament on the stretch the joint is readily entered, and by flexing the wrist the extensor tendons and dorsal ligaments are rendered taut

and are divided. The structures on the flexor aspect and the remaining lateral ligament are next cut through.

The radial, the ulnar, and the terminal branches of the interosseous arteries having been secured, and the median and ulnar nerves pulled out and cut across in the usual way, the flexor and extensor tendons are stitched to each other across the face of the stump, so that the function of the muscles of the forearm may to some extent be preserved.

The scar being terminal falls in the hollow between the two styloid processes and is therefore not pressed upon by the circular strap which secures the artificial hand.

The *elliptical method* is to be preferred when the injury or disease involves the skin on the dorsum that is required in the circular method. The highest point of the ellipse is on the dorsum at the level of the tip of the radial styloid, and the lowest point in the palm about two and a half inches lower down. The obliquity of the incision may be increased if necessary.

In the method by *long palmar flap* the incision which marks out the flap starts below the radial styloid, crosses the palm a little above the level of the fully abducted thumb, and finishes off half an inch below the ulnar styloid.

The flap tapers slightly towards its free extremity, and when raised should contain all the soft parts down to the flexor tendons, namely, the muscles in the thenar and hypothenar eminences, the palmaris longus, the median nerve, and the terminations of the ulnar artery and nerve; if the pisiform bone is healthy, it should also be raised with the flap. The dorsal incision is then made, the skin and fat being divided by a straight cut joining the ends of the palmar incision, and the extensor tendons at the level of the retracted skin. After the ligaments have been divided, the operation is completed by severing the mass of flexor tendons.

A *single external flap*, taken from the radial side of the thumb and including the muscles forming the thenar eminence, may be employed when no tissue from the ulnar side of the hand is available.

**Amputations through the Forearm.**—In amputating through the forearm that method which will yield the longest stump is to be selected, and if possible the bones should be divided below the insertion of the pronator radii teres, so that some degree of pronation and supination is possible. The longer the stump is, the greater control the patient has over the artificial limb, and a stump which can be pronated and supinated is much more useful than one which can only be flexed and extended.

After these amputations the bones lose the support derived from the inferior radio-ulnar joint, and their lower ends tend to fall together and become fused.

**In its lower third** the forearm is cylindrical in shape, and the *circular* is the method of choice. With the limb held in the position of complete supination, a circular incision is made through the skin and fat, and a cuff of integument is turned up. About an inch below the level at which the bone is to be sawn, the remaining soft parts, which consist chiefly of tendons, are divided, either by cutting from without inwards or by transfixion. The knife is then thrust between the bones to divide the remaining muscular fibres and the interosseous membrane. With the limb still in the supinated position the saw is applied close up to the retracted muscles, and the section of the radius should be completed first as the ulna is the more fixed bone.

The radial, ulnar, and interosseous vessels are secured, and the median and ulnar nerves pulled out and shortened in the usual way. The skin edges are approximated with sutures, the cicatrix falling opposite the ends of the bones.



The stump is placed in the position midway between pronation and supination, bandaged to an internal rectangular splint, and supported by a sling.

As soon as the wound has healed, massage is commenced, movements of pronation and supination are carried out, and the patient is encouraged to exercise the muscles.

When the soft parts are destroyed unequally on the two aspects of the limb, the *elliptical method* should be employed, or the covering should be formed by making *unequal flaps*.

**In its upper two-thirds** the forearm is conical, and there is some difficulty in reflecting a cuff of integument formed by a circular incision. It is better, therefore, to form *two semilunar or U-shaped flaps* of skin, fat, and fascia, about two or three fingers' breadth in length, dividing the muscles at the base of the flaps, and sawing the bones at a higher level.

In other respects the operation is the same as for amputation in the lower third.

A *racket-shaped incision*, the handle of the racket being placed over the posterior border of the ulna, is recommended by Koehler.

**Disarticulation at the Elbow.**—In planning this operation it is necessary to provide ample flaps to cover the broad condylar end of the humerus. The breadth of the stump, as compared with that resulting from amputation above the condyles, favours the fitting of a satisfactory artificial limb and gives the patient greater control over it. Whatever method of forming the covering for the bone is adopted, it will be found that disarticulation is best effected from the radial side, the knife entering the joint between the head of the radius and the capitellum.

*By the Circular Method.*—An operation performed on the same lines as that for disarticulation at the knee, suggested by A. G. Miller, is the method of choice.



The incision dividing the skin and faseia should pass round the limb obliquely, extending about three fingers' breadth below the line of the joint on the radial side, and only two fingers' breadth on the ulnar side. In this way the greater retraction of the muscles on the radial side is provided for, and the flaps are equalised. The limb should be fully extended and supinated while the incisions are being made. By

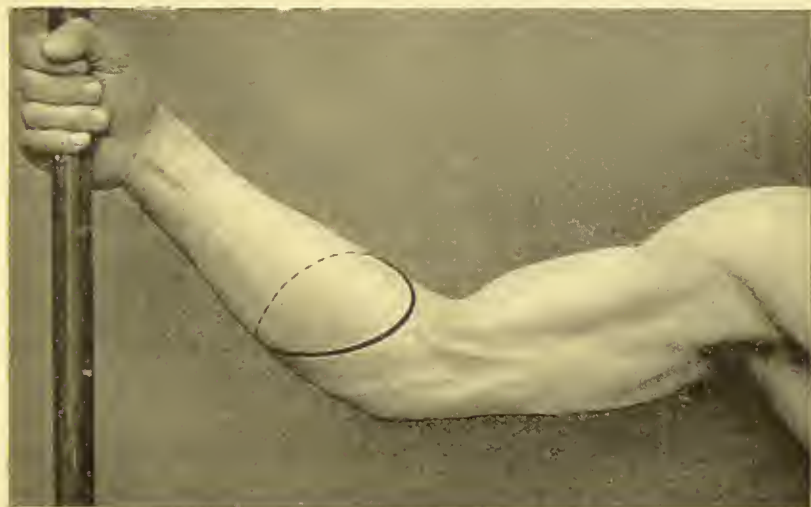


FIG. 119.—Disarticulation at Elbow by Elliptical Incision.

putting the ligaments on the stretch seriatim, disarticulation is easily effected. By bending the fore-arm backwards the triceps attachment is exposed, and can be divided from the front.

The vessels to be secured are the brachial or the radial and ulnar, according to the level of section, and the terminal branches of the superior and inferior profunda and anastomotie arteries. The median nerve is found to the ulnar side of the biceps tendon, and the ulnar nerve behind the internal condyle, and both are shortened.

In employing the *elliptical method* (Fig. 119) the upper end of the ellipse is placed on the flexor aspect at the level of the fold of the elbow, and the lower end on the extensor aspect a hand's breadth below the joint, thus securing a covering of skin which is accustomed to bear pressure. In raising the soft parts posteriorly the periosteum of the ulna and the insertions of the triceps and anconeus should be stripped off the bone (Kocher).

If the skin on the back of the limb is not available, the direction of the ellipse may be reversed, as in the operation devised by Farabœuf.

**Amputations through the Upper Arm.**—The circular method being the most economical of tissue, and furnishing a terminal scar which does not interfere with the attachment of an artificial limb, is to be preferred when the destruction of skin is equally distributed around the limb. When the soft parts are damaged more on one aspect than on another, the elliptical or the flap method enables a longer stump to be left.

Whatever method is employed, the upper arm is held horizontally and is abducted to a right angle.

The hæmorrhage is controlled by an assistant compressing the subclavian artery against the first rib, or by isolating and securing the brachial vessels before they are cut across. A tourniquet may be employed for amputations in the lower third of the upper arm, but higher than this there is difficulty in preventing it slipping downwards unless it is retained in position by steel pins transfixing the limb, or by an arrangement of bandages, and these are apt to be in the way.

*Circular Method.*—The site of bone section having been determined, a circular incision is made through the skin, fat, and fascia at a distance below that equal to about the diameter of the limb. By circular sweeps

of the knife, the surgeon divides first the superficial and then the deep museles. The deltoid, coraeo-brachialis, and bieeps museles being free, retract more than the braehialis anticus and trieeps which are attached to the bone. The soft parts are then retracted, speeial eare being taken that the musculo-spiral nerve is removed from its groove and eut aecross, and the saw is applied at the site selected.

In the lower third of the arm the braehial artery will be found on the front of the bone, in the upper two-thirds towards its inner side. The median nerve lies in front of the artery, the ulnar to its inner side, and the musculo-spiral nerve, aecompanied by the superior profunda artery, lies behind or to the outer side of the bone.

The vessels and nerves having been dealt with as usual, the museles are stitched to each other over the end of the bone, and the edges of the skin are sutured in the horizontal plane.

When the *elliptical method* is employed the higher end of the ellipse should lie over the inner bieiepital suleus (Kocher).

If the *flap method* is adepcted the flaps should be external and internal, as it is alleged that when anterior and posterior flaps are employed, the deltoid is liable to abduet the bone and projeet it against the outer angle of the wound where the two flaps meet.

**Disarticulation at the Shoulder-Joint.**—The method selected for disarticulation at the shoulder-joint will be determined to a large extent by the nature of the lesion which neecessitates the operation. In cases of injury, the irregular destruction of skin and other soft parts limits the selection of flaps to the least damaged area. When the operation is done for malignant disease the ineisions must be planned so as to include in the covering the parts most remote from the new growth. The

condition of the humerus also influences the selection,—when it is intact the method associated with the name of Spence is suitable; when its continuity is broken either by injury or by disease, the Furneaux-Jordan method is to be preferred.

Hæmorrhage is best controlled by securing the main

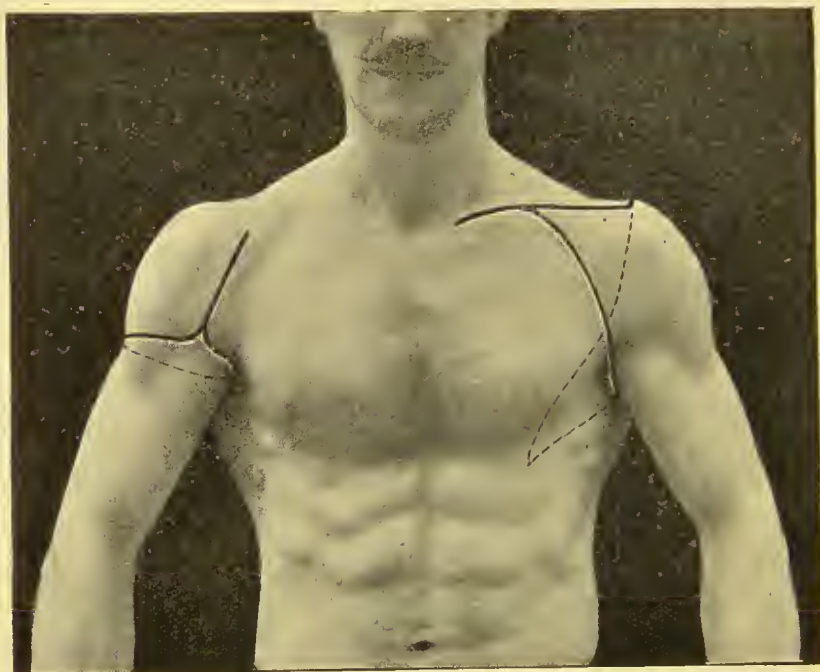


FIG. 120.—Incisions for Amputation of Right Shoulder, and for Interseapulo-thoracic Amputation—Left.

vessels before they are divided. It is impossible to apply a tourniquet, and compression of the subclavian artery is unreliable and interferes with the manipulations of the operator.

The surgeon may manipulate the upper arm with his left hand, which has the advantage of enabling him to clear the head of the bone with greater precision, or he may entrust the limb to an assistant and use his

own left hand to retract the soft parts as they are divided.

*Spence's Operation.*—The limb being slightly abducted and the upper arm rotated outwards, the point of a strong knife is entered immediately to the outer side and slightly above the coracoid process, so that it at once enters the shoulder joint and impinges on the head of the bone. With a sawing movement the knife divides the soft parts in the line of the bicipital groove, cutting through the clavicular fibres of the deltoid and the sternal fibres of the pectoralis major. With a gentle curve the incision is carried across the outer and posterior aspect of the limb, dividing the lower fibres of the deltoid; but on reaching the inner aspect of the arm, as it passes over the main vessels, the incision is carried through the skin and fat only. The deltoid flap, with the posterior circumflex artery entering its deep surface, is then raised from the bone and held out of the way by an assistant, thus exposing the head and tuberosities of the humerus. The tendinous insertions of the capsular muscles, the long head of the biceps, the capsule itself, and the broad tendon of the subscapularis are divided one after another by cutting directly upon the anatomical neck and tuberosities—the arm being rotated, first inwards and then outwards, to expose these various structures in the vertical part of the incision. The head of the bone is protruded at the wound by forcibly depressing the elbow, and the disarticulation is thus completed. The knife is then inserted between the humerus and the soft parts on the inner side, by which alone the limb is connected to the trunk, and, the edge being kept close to the bone, these are divided, first from above downwards and then from within outwards, the last parts to be cut being those opposite the superficial portion of the original circular incision. The main vessels may be exposed and secured with



forceps before they are divided, or, following Spence's practice, the assistant may follow the knife as it divides the structures on the inner side and grasp the artery before it is cut. The latter method is not free from danger, as the great mobility of the artery may cause it to slip from the fingers of an unskilled assistant. The nerve trunks are dealt with in the usual way, the muscles sutured, and the wound closed so as to leave a vertical cicatrix.

*Furneaux-Jordan's Method.*—In this proceeding, which resembles the corresponding operation at the hip, it is possible, after emptying the limb of blood, to apply an elastic tourniquet to the junction of the arm with the trunk, and to prevent it from slipping either by skewers transfixing the limb, or by means of an elastic band applied as a figure-of-eight underneath the opposite shoulder. A circular amputation is performed at the level of the lower fibres of the deltoid, and the bone is divided at the level of the retracted soft parts. The vessels are secured, after which the tourniquet is removed and any other bleeding points attended to. A vertical incision is now made in the line of the bicapital groove, and the upper end of the humerus is cleared and removed as in excision of the shoulder; or, if the periosteum is healthy, the bone may be shelled out so as to preserve that membrane and its bone-forming functions.

This method is specially indicated when the humerus is smashed, or when skilled assistance is not available, and it should be preferred to Spence's when it is possible to preserve the periosteal investment of the bone.

A. G. Miller has devised a method of disarticulating at the shoulder by a *circular incision* placed about a hand's breadth below the acromion process.

Amputation at the shoulder by means of *skin flaps* in cases of malignant disease of the upper end of the humerus is not to be recommended, because when a

radical removal of the disease is aimed at the scapula with its muscles should also be removed.

**Interscapulo - thoracic Amputation.**—This operation, perfected by Berger in 1887, is most commonly performed for injury and for malignant disease of the upper end of the humerus, but it is sometimes indicated in acute gangrene and other infective conditions.

The first step in the operation is the exposure and ligation of the main vessels where they pass beneath the clavicle. The incision employed is racket-shaped, and that portion which forms the handle of the racket begins at the sternal end of the clavicle and passes along the entire length of that bone. The periosteum of the clavicle is incised and stripped and the bone divided, preferably with a wire saw, at the junction of its inner and middle thirds, thus permitting the outer and longer portion of the bone to be drawn outwards with a hook. Some surgeons prefer to resect the middle third of the bone. The subclavius muscle and its fascia are carefully divided to expose the main vessels and nerves; the nerves are blocked by injecting novocain into them, and are cut across with a knife rather than with scissors, one after another. The artery is next secured by two ligatures and divided between them, and then the vein is similarly dealt with; the limb may be elevated to empty it of blood before the vein is tied.

Hæmorrhage in the later stages of the operation may be reduced to a minimum by securing also those branches of the subclavian that pass outwards in front of the scaleni—the superficial and ascending cervical, the supra-scapular, and the transversalis colli. This procedure, however, prolongs the operation, and it is not always advisable to adopt it. If a skewer is used, it is passed down behind the clavicle between the scapula and the chest wall, and brought out in the axilla; the elastic

tourniquet is then applied in front in the form of a figure-of-eight.

These precautions against hæmorrhage having been taken, the arm is abducted to a right angle with the trunk, and the flaps are mapped out by carrying a skin incision downwards across the front of the shoulder from the centre of the incision along the clavicle to the anterior fold of the axilla, then across the inner aspect of the arm to the posterior axillary fold, and thence down the chest wall to the inferior angle of the scapula (Fig. 120).

The pectoral muscles are cut across, and the vessels related to them secured. The dissection is continued along the outer wall of the thorax towards the ventral surface of the scapula, any infected glands that may be present being raised from the surface of the serratus magnus. The latissimus dorsi is divided close to its insertion, unless the presence of infected glands should call for its division nearer the thorax.

The limb is now forcibly drawn across the trunk towards the opposite side, and the patient partly rolled over so as to expose his back. It is then possible to complete the blade of the racket, by continuing the incision through skin and fascia from the outer end of the incision along the clavicle to the inferior angle of the scapula (Fig. 120).

The skin and fascia are raised by dissection, and the attachments of the trapezius to the spine of the scapula, of the levator to the superior angle, and of the rhomboids to the vertebral border, are divided in succession, and the omo-hyoid is then detached from the upper border. The division of these muscles is more easily accomplished if they are made taut by drawing the scapula away from the trunk. If the branches of the posterior and supra-scapular arteries have not already been secured they must be seized with forceps as they are divided.

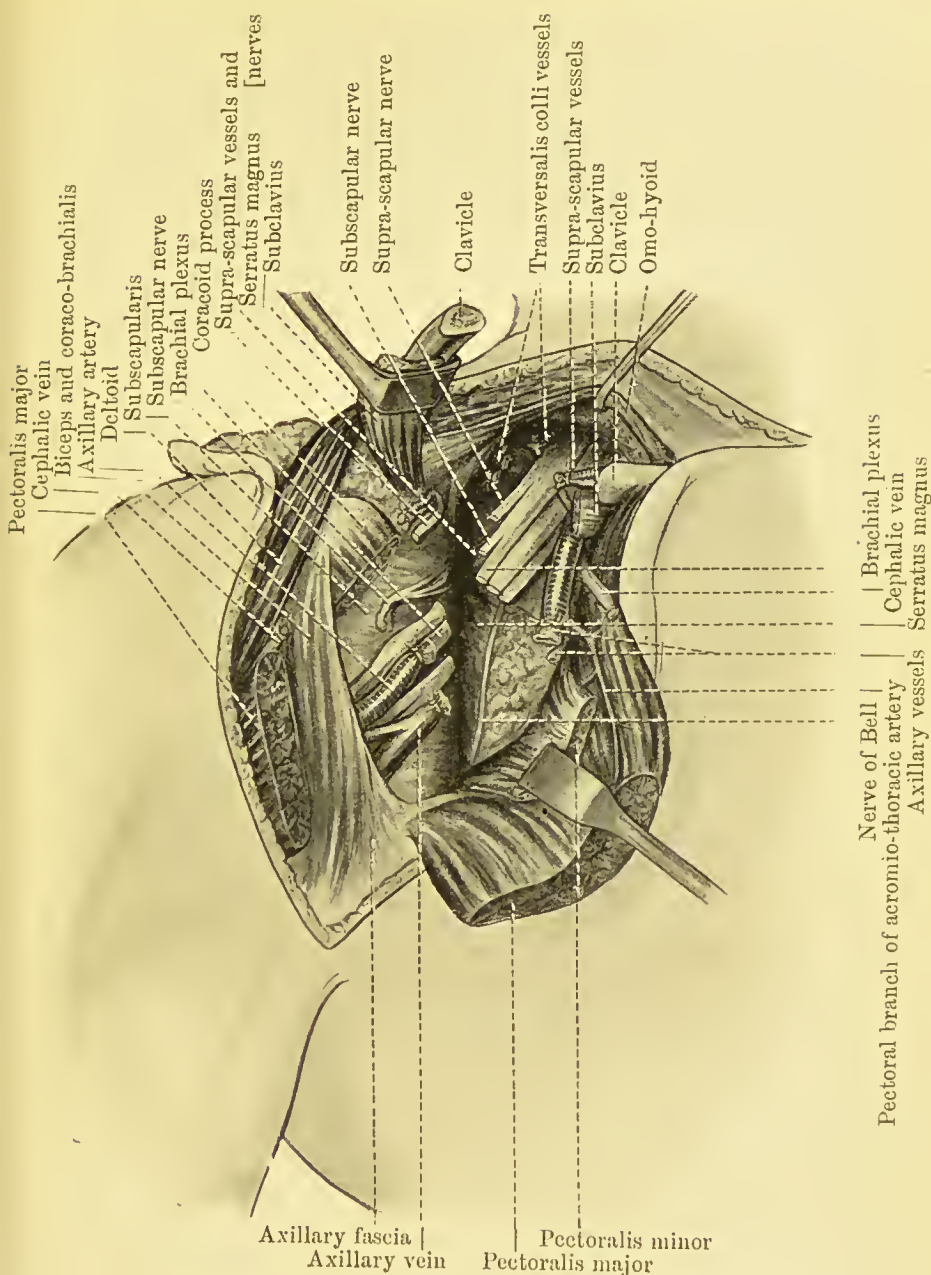


FIG. 121.—Interscapulo-thoracic Amputation, 1st stage.

If the skin flaps necessary for the operation as described above are not available, a covering may be

obtained elsewhere, as, for example, from the upper arm (Keen). Drainage is best secured by bringing a small tube through an opening made for the purpose in the posterior flap. The skin edges form a comparatively small linear wound running downwards and outwards.

The operation is not an easy one to perform, and we have experienced some difficulty in controlling the bleeding from the supra-scapular and other veins running into the main trunk behind the clavicle. In separating the structures attaching the scapula to the chest wall we have found it an advantage to have the arm forcibly pulled from the side, and to grasp the scapula with the left hand and divide the muscles with a probe-pointed knife.



## CHAPTER XVI

### OPERATIONS ON SKULL AND BRAIN

TREPHINING. WAGNER'S OSTEOPLASTIC OPERATION. OPERATIONS FOR INTRACRANIAL HÆMORRHAGE: *Middle meningeal hæmorrhage; Hæmorrhage from venous sinuses; Intracranial hæmorrhage of newly-born.* OPERATION FOR TRAUMATIC EPILEPSY. OPERATION FOR TRAUMATIC INSANITY. OPERATIONS FOR INJURIES OF SKULL: *For compound fractures; for simple fractures; for fractures of base; for bullet wounds.* OPERATIONS FOR INTRACRANIAL SUPPURATION: *For extradural abscess; for temporal abscess; for cerebellar abscess.* OPERATIONS FOR CEPHALOCELES: FOR HYDROCEPHALUS; FOR CEREBRAL TUMOURS; FOR CEREBELLAR TUMOURS; FOR TUMOURS OF ACUSTICUS. DECOMPRESSION OPERATIONS. OPERATIONS FOR REMOVAL OF GASSERIAN GANGLION. OPERATIONS ON THE HYPOPHYSIS CEREBRI. OPERATIONS FOR MASTOID DISEASE. OPERATION ON FRONTAL SINUS.

THERE are two methods of opening the skull: (1) by *Trephining*, in which a disc of bone is removed by means of the classical hand-trephine, and the opening in the skull enlarged, if necessary, by nibbling with rongeur forceps; and by (2) *Craniotomy*, or the raising of a flap of bone together with the overlying area of scalp in one piece—*Wagner's osteoplastic operation*.

**Trephining.**—In this country trephining is still the routine method employed in the great majority of cases in which a positive diagnosis as to the site and nature of the lesion can be made,—for example, in cases of intracranial hæmorrhage or suppuration, localised cysts,

depressed and other fractures of the vault, or bullet wounds.

For tumours which cannot be definitely localised, or for traumatic epilepsy where it may be necessary to explore a considerable area of the brain, the osteoplastic operation is preferable.

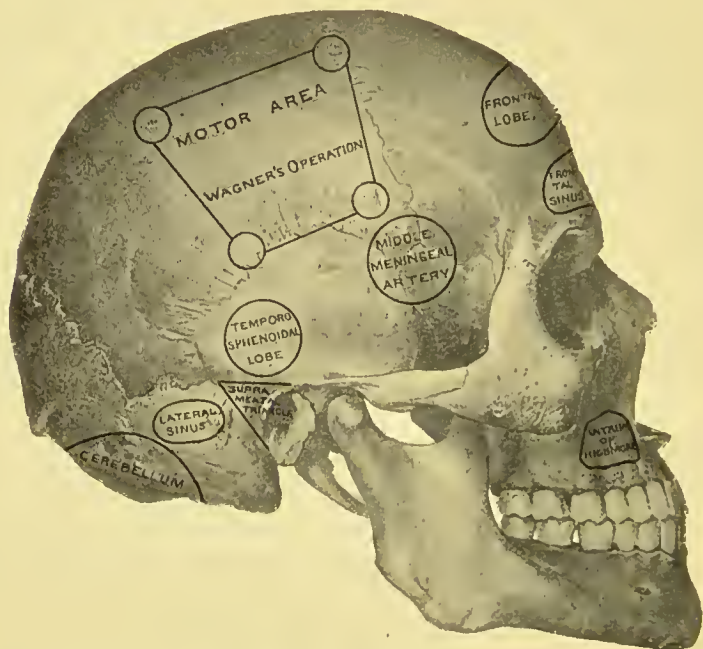


FIG. 122.—To illustrate the Sites of Various Operations on the Skull.

*Preparation before Operation.* — The general preparation of the patient is carried out in the same way as for other major operations. Cushing recommends the administration of urotropin for some days before operation, as this drug is excreted into the cerebro-spinal fluid and acts as an antiseptic. The whole scalp should be shaved the day before operation, purified by washing, and covered with sterile gauze retained in position by a bandage. The abundant

blood supply of the scalp renders it comparatively immune to septic infection, and some surgeons, notably Cushing, relying upon this, dispense with all preliminary preparation until the patient is on the operating table. The sterilised towels surrounding the field of operation are conveniently kept in position by means of a few silkworm-gut stiches fixing them to the scalp.

*Anæsthesia.* — We have found it of considerable advantage to inject scopolamin (one-hundredth grain) and morphin (half grain) before operation, and we prefer ehloroform to ether as a general anæsthetic, as it lowers the blood pressure and causes less congestion of the cerebral vessels, and so diminishes the amount of oozing. The anæsthetic must however, be carefully administered, as the lowering of the blood pressure may become a source of danger and there is considerable risk of paralysis of the respiratory centre. To diminish these risks oxygen should be administered along with the ehloroform (Horsley).

The patient should be placed in a reclining position, (30 degrees), with the head resting on a firm sand-bag or other support.

*Prevention of Shock.* — Brain operations are attended with considerable shock, which is partly due to hæmorrhage, and partly to extensive opening of the cranial cavity disturbing the intracranial tension, and so affecting the functions of the cardiac, respiratory, and vasomotor centres. The temperature of the room must not be below 75° F., and the operating table should be suitably heated or the patient surrounded with hot bottles.

Horsley lays considerable stress on the importance of allowing a constant stream of saline solution at a temperature of 115° F. to flow over the brain during the whole time it is exposed. Bleeding should be thoroughly controlled, and the brain should be handled

as little and as gently as possible. The more quickly the operation is performed the less is the shock.

As a further precaution in extensive operations, such as the removal of a cerebral tumour or an operation for epilepsy, Horsley and Krause recommend that the operation be performed in two stages—the first consisting in opening the skull; the second, undertaken from six to fourteen days later, in opening the dura and dealing with the intracranial lesion. This also lessens the risk of sudden hernia cerebri and widespread paralysis (Cushing). As the brain is insensitive an anæsthetic may be dispensed with at the second operation.

*Control of Hæmorrhage.*—The most convenient means of diminishing bleeding from the scalp and bone is to apply a piece of stout rubber tubing or a Bier's elastic bandage round the head from the glabella to the suboccipital region, with a piece of tape passing along the vertex to prevent the tourniquet slipping down over the eyes and on to the nape of the neck. In this way the frontal, temporal, and occipital vessels are controlled.

Temporary ligation of the main vessels in the neck (Crile), and the passage of subcutaneous sutures through the scalp at the base of the flap so as to grasp the feeding arteries (Kradel), are alternative methods.

The divided vessels should at once be caught with forceps and ligated; any bleeding vessel that cannot be so secured may be encircled with a catgut suture.

In separating the pericranium, considerable bleeding may occur from emissary veins, especially in the mastoid region, in the posterior fossa, and over the transverse and longitudinal (sagittal) sinuses. This may to some extent be prevented by pulling the veins gently out of their foramina and securing them with forceps and ligature, or by throwing a ligature round them with the aid of an aneurysm needle.

Bleeding from the diploë is seldom serious, and can

usually be arrested by pressure or by the application of Horsley's antiseptic putty, which consists of carbolic acid one part, olive oil two parts, and beeswax seven parts. If a large sinus in the bone bleeds, it may be plugged with a chip of bone removed from the skull or a small ivory peg, or the portion of bone may be crushed with forceps. Sometimes the middle meningeal artery runs in a canal in the bone instead of in a groove in the vitreous table, and is divided in sawing the bone; bleeding from it is best stopped by plugging.

The most dangerous bleeding, however, occurs from the meningeal vessels, particularly the larger veins where they widen out into broad sinuses before opening into the great intracranial sinuses. The arterial bleeding is seldom difficult to control. The area supplied by the middle meningeal is the most dangerous. The branches can usually be seen, and should be encircled by fine catgut passed with a short round needle, or by fine silver wire clips.

*Cutting of Flap.*—When the scalp is intact, a horse-shoe shaped flap with its base downwards is reflected, and if possible it should be planned so as to have the temporal or occipital artery running in its base.

The incision is carried down to the bone, and the pericranium is reflected along with the scalp. Any emissary veins should be gently pulled out of their foramina and caught with forceps, or encircled with a ligature with the aid of an aneurysm needle.

The trephine is then applied. The centre pin is pushed into the bone as far as it will go, and with short sharp movements the sawing edge of the instrument is worked into the bone, pressure being made only with the movement of supination, as it is only in this direction that the saw bites. As soon as a uniform groove has been made by the saw, the centre pin is removed, and the sawing is continued until the diploë



is entered. This is recognised by the oozing which takes place from the groove, and by observing that the tissue is softer and offers less resistance. As the thickness of the bone varies at different parts of the skull, care must be taken to avoid perforating the bone at one part of the circle sooner than at another. From time to time the trephine should be removed and its teeth cleared of bone dust by rinsing it in sterile salt solution and rubbing it with a gauze swab. The depth of the groove in the bone is estimated from time to time by means of a sterilised toothpick or probe.

After the diploë has been traversed and the trephine reaches the vitreous table, it meets with more resistance, and great care must be taken to saw this table evenly and not to go through it suddenly.

When the circle has been isolated it frequently comes away in the trephine; if not, it can easily be removed with the aid of an elevator. No attempt should be made to prise it up until the vitrea has been sawn through completely, otherwise this table is liable to be splintered, or the circle may only contain the outer table and diploë.

In children before the diploë is developed, and in the temporal and suboccipital regions in adults, the bone is specially thin. In children the dura mater is closely adherent to the vitrea.

If it is necessary to enlarge the opening this may be done with rongeur or gouge forceps, or other cutting instrument.

*Opening of Dura Mater.* — This is best done by cutting a flap. When near the longitudinal sinus the base of the flap should be towards the sinus; when near the floor of the skull, it should be downwards, to avoid cutting the larger vessels which run towards the vertex.

The incision in the dura should not be made flush with the bone, as it may be desirable to suture the flap

in position again. A crucial incision with folding aside of four small flaps does not give sufficient room.

Any vessel seen crossing the line of the projected incision in the dura should be secured before division by being encircled with a fine catgut suture carried on a small round needle and tied above and below the point of section. The dura is picked up with toothed forceps and incised, great care being taken not to injure the subjacent arachno-pia.

The further steps of the operation vary with its purpose and will be referred to later.

### **Craniotomy or Wagner's Osteoplastic Resection of Skull.**

—This operation is to be preferred to trephining in cases in which it is necessary to expose a considerable area of the brain in order to deal with an extensive tumour, and when the operation is primarily an exploratory one to determine the precise situation and nature of the intracranial lesion.

The preliminary steps are the same as for trephining.

*Formation of Osteoplastic Flap.*—As the success of this procedure depends to a large extent on reflecting the scalp, pericranium, and bone in one piece so that the vitality of the bone is preserved through its vascular connections with the soft parts, it is of great importance to plan the steps of the operation in such a way as to diminish the risks of separating the scalp from the bone. We have found that this is best effected by carrying out the operation in the following manner.

The area of bone to be reflected is delimited by making a scratch with a needle on the scalp at each of its four corners.

The incision in the scalp is eventually to be omega-shaped ( $\Omega$ ), but to begin with only the curves of the omega opposite each corner are made (Fig. 123). Each of these incisions goes down to bone, and the small

flaps are reflected. With a  $\frac{1}{4}$ -inch trephine a circle of bone is removed at each corner. A flexible grooved director is then passed between the bone and the dura mater, and along this director is slipped the Gigli saw, with or without the aid of an introducer, and each of the four sides of the bone flap is in turn sawn through from within outwards, care being taken to cut the bone obliquely so that the surfaces are

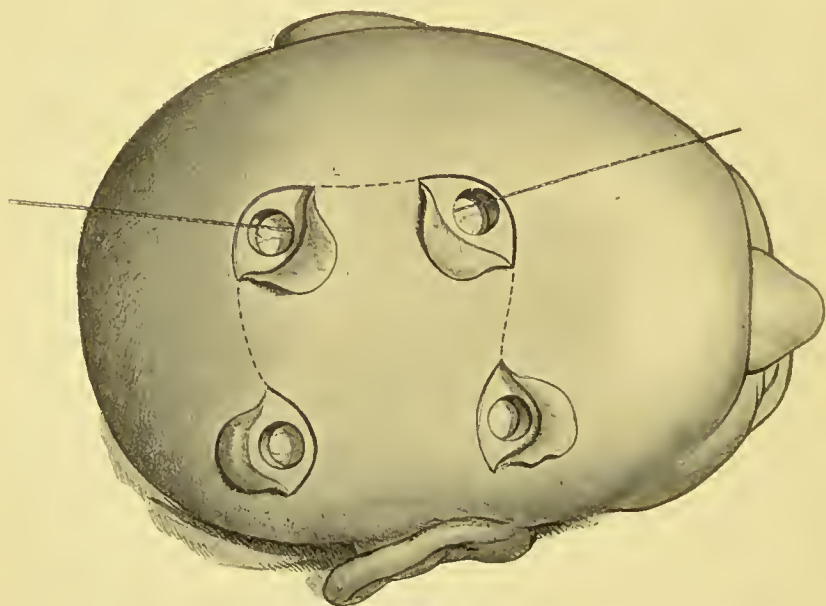


FIG. 123.—Wagner's Osteoplastic Resection of Skull, 1st stage.

bevelled (Fig. 124). The advantage of this is that when the osteo-eutaneous flap is replaced the bevelling prevents it sinking in upon the dura mater (J. M. Cotterill).

After the four sides of the bone flap have thus been divided, an elevator is passed in at the two upper trephine openings, and, the intact skull edge acting as a fulcrum, the bone is gently raised.

The omega ( $\Omega$ ) incision is now completed (Fig. 124).

The osteo-eutaneous flap can now be turned down-

wards on its base. As this is being done the dura mater is gently separated from its deep surface.

The flap is now wrapped in gauze wrung out of hot saline solution, and to avoid unnecessary handling with the attendant risk of separating the scalp from the bone, it may be secured by one or two silk-worm gut sutures to the skin of the neck.

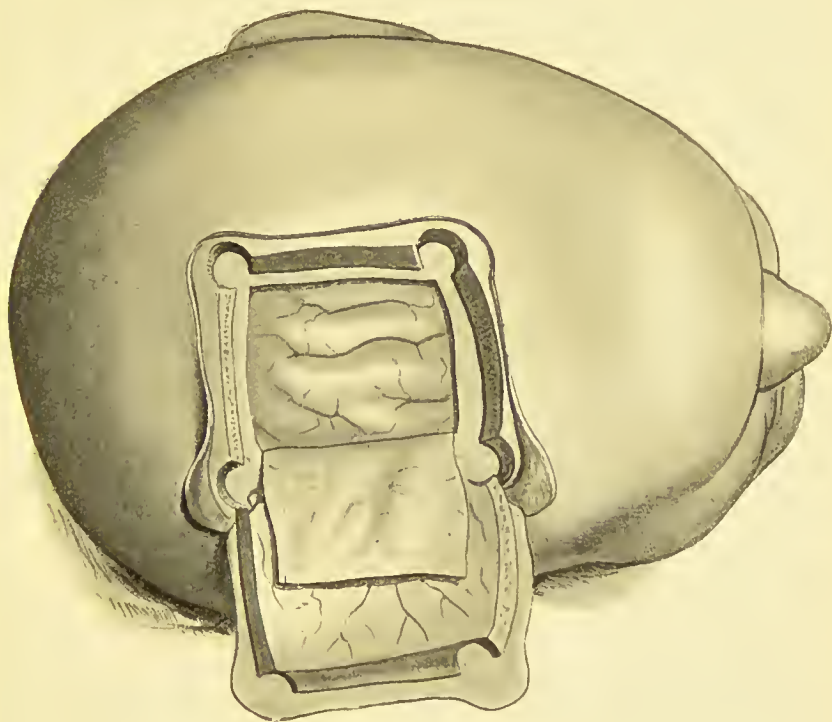


FIG. 124.—Wagner's Osteoplastic Resection of Skull, Brain exposed.

We have never found the hæmorrhage up to this point troublesome or excessive.

At this stage the tension of the dura mater, the pulsation of the brain, and the consistence of the underlying cortex should be noted. A localised tumour of the cortex may be recognised by the fact that the brain pulsations cannot be felt through the dura, and sometimes the colour of the dura over the tumour is altered.

Occasionally the tumour can be felt as a firm swelling, but as a rule the tension of the dura obscures this sign. Non-encapsulated growths cannot be recognised.

The dura mater is then opened, the incision being made about an eighth of an inch away from the bone (Fig. 124), so that a projecting edge is left which will admit of the dura being sutured before the flap is replaced. Any vessel seen crossing the line of the projected incision should be secured before division. The dura is picked up with toothed forceps and incised, great care being taken not to injure the subjacent arachno-pia.

The flap of dura mater having been reflected, the exposed area of the brain is examined. A tumour of the cortex, an arachnoid cyst, or a cyst in the brain matter may be visible on the surface, or may be recognised by palpation as a firm or elastic swelling differing in consistence from the surrounding brain substance. When a subcortical tumour is present the convolutions are flattened, the sulci obliterated, and the cortex presents a dry, lustreless appearance (Krause). Such tumours cannot be located by palpation, and it is necessary to explore the brain by means of an aspirator needle or a probe.

The next point of importance is whether the tumour is encapsulated or diffuse. Localised tumours of the cortex can usually be shelled out with comparatively little bleeding or injury to the brain substance. Those forms of cyst which have connective-tissue walls can similarly be shelled out; but in the case of thin-walled cysts we must be content, after withdrawing the fluid, to remove as much of the wall as possible and pack the cavity with gauze, to favour healing by granulation.

The bleeding associated with these procedures is best arrested by light gauze packing. Attempts to secure the vessels with forceps only result in injuring the brain tissue. The large veins of the arachno-pia should



be pushed aside, as their ligation may cause paralysis (Cushing). If large vessels can be seen entering the growth, they should be secured by passing a double catgut ligature round them and dividing between. Subcortical tumours are frequently capable of being enucleated—the overlying cortex being incised to admit the finger for this purpose.

If it is found that the tumour is diffuse—for example, glioma or sarcoma—no attempt should be made to remove

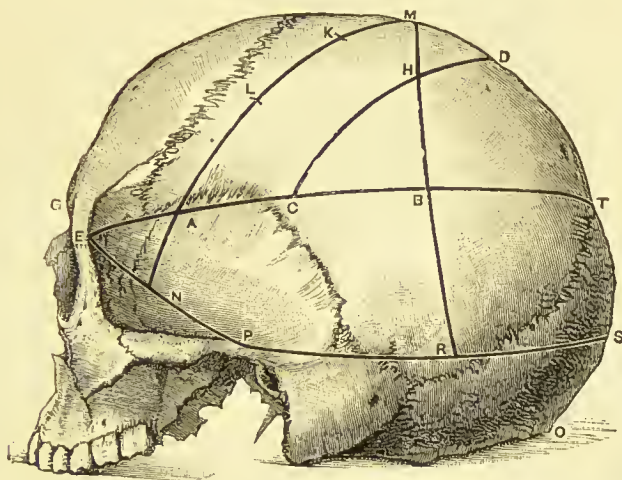


FIG. 125.—Chiene's Method of Cerebral Localisation.

(See Vol. II. p. 16.)

it; considerable benefit usually results from the relief of intraeranian tension.

*Closure of Wound.*—If the tumour has been removed, the flap of dura mater is stitched in position with catgut sutures, an opening being left for the emergence of any gauze pack that may have been inserted, or for a drainage tube, the osteo-eutaneous flap replaced, and the scalp sutured.

If removal of the growth has not been possible, the dura is not closed, and it may be advisable to remove the bone from the flap in order that the brain may

bulge through the opening. The scalp is sutured with or without drainage, according to circumstances.

**Operation for Middle Meningeal Hæmorrhage.**—*For*

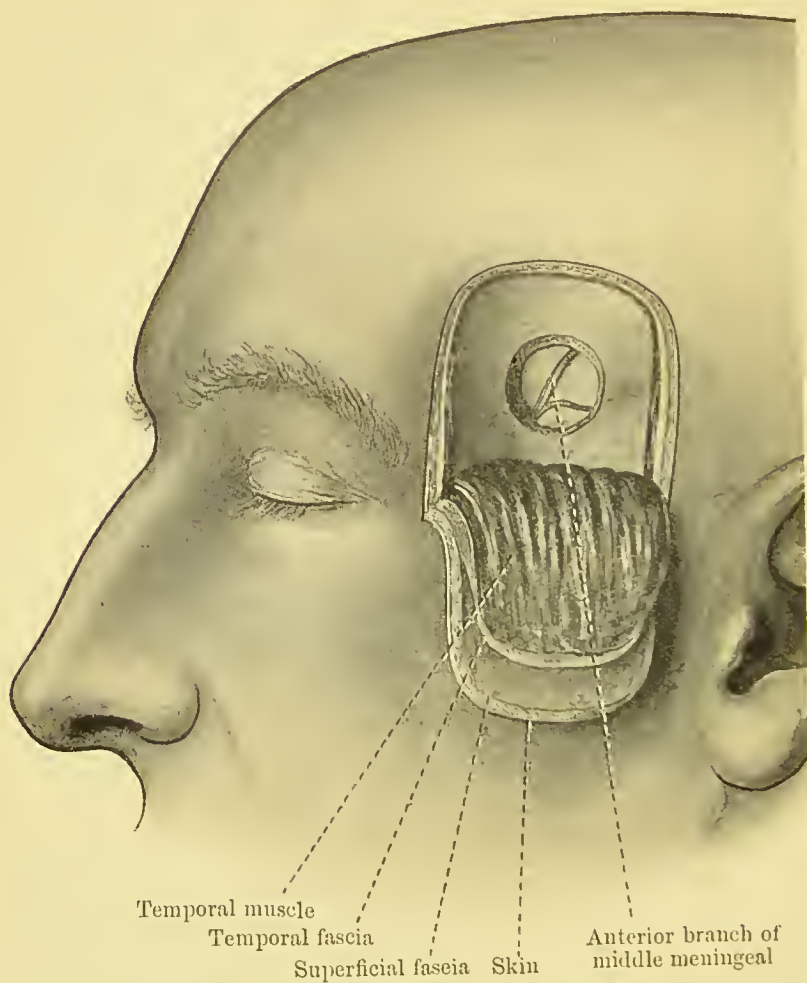


FIG. 126.—Exposure of Anterior Branch of Middle Meningeal Artery.

*Hæmorrhage from the Anterior Branch.*—The anterior branch of the middle meningeal crosses the anterior inferior angle of the parietal bone at a point (A) opposite the intersection of the lines E T and M N (Fig. 125) which lies about two inches behind and above the

external angular process. A horseshoe-shaped flap including everything down to the bone is reflected and the temporal fossa exposed. With a  $\frac{1}{2}$ -inch trephine the disc of bone is removed, and the groove for the artery is usually found on its deep aspect. The extra-dural clot is removed, and the damaged artery sought for. In many cases the bleeding has already ceased, but the artery should always be secured above and below the bleeding-point if possible. This may necessitate enlarging the opening in the skull with rongeur forceps upwards or downwards according to circumstances. When the vessel is exposed it should be encircled with a catgut ligature above and below the bleeding-point. Occasionally the only means of controlling the hæmorrhage is by packing with gauze. Sometimes the artery runs in a canal, and the bleeding can only be arrested by driving a small fragment of bone chipped from the trephine circle into the canal.

If the bleeding is taking place from the artery near its emergence from the foramen spinosum, the dura mater must be stripped from the floor of the middle fossa and sufficient bone removed with rongeur forceps to give access to the foramen, into which a fragment of bone is forced.

The bleeding having been arrested, the flap is replaced and sutured in position, provision being made for drainage at the posterior corner of the wound, or by making a slit in the base of the flap.

*For Hæmorrhage from the Posterior Branch.*—The posterior branch of the artery is exposed by removing a trephine circle from a point about an inch above and behind the external auditory meatus. The steps of the operation are similar to those for exposure of the anterior branch.

**Operation for Hæmorrhage from Venous Sinuses.**—The *great longitudinal (superior sagittal) sinus* is occasionally

torn in cases of comminuted and depressed fracture of the vertex, and the effused blood may collect between the bone and the dura where it forms a limited hæmatoma, or it may pass into the arachno-pial space and spread over a wide area of the brain. If the fracture is compound the blood may escape externally.

Sometimes a fragment of bone is driven into the sinus, and bleeding only occurs when this fragment is disturbed in the course of the operation for elevating the depressed bone.

While the measures described on page 280 for dealing with the comminuted bone are being carried out, it may be necessary to plug with gauze that portion of the wound from which the blood is flowing; and if, after the fragments have been removed or elevated, the bleeding point is not clearly exposed, the opening in the bone must be enlarged with rongeur forceps.

Firm pressure with a pad of gauze is usually sufficient to control the bleeding temporarily.

If possible the rent in the wall of the vein should be closed by lateral sutures of fine catgut or silk introduced with a round intestinal needle in such a way as to preserve the lumen of the sinus.

If this is not practicable, the dura, after being freed sufficiently, may be raised and made to cover the opening by a series of sutures introduced after the method of Lembert's peritoneal sutures.

If the wound in the vessel wall is large and irregular, or if the sinus is torn across, a catgut ligature must be thrown round the sinus on each side of the damaged area, small incisions being made through the dura to admit of the aneurysm needle being passed. If these measures fail, a strip of gauze should be packed in between the bone and the dura sufficiently tightly to occlude the vessel. This packing is left in for several days.



If blood has been effused into the arachno-pial space, as much of it as possible should be removed, and drainage provided for, a counter-opening being made through the dura, if necessary, at the most dependent part of the effusion.

**Operation for Intracranial Hæmorrhage in the Newly-Born.**—The operation consists in exposing the motor area, which is the most common site of the extravasation, either by trephining or by raising an osteoplastic flap. The dura is opened, the clot removed, and the wound closed without drainage.

Cushing, as a result of his experience of twelve cases operated upon, some on both sides, expresses the opinion (1910) that "the procedure is a delicate and difficult one, and until much more can be learned regarding the late results and the best methods of procedure I do not feel that it can be widely advocated for general use."

**Operation for Traumatic Epilepsy.**—As the fits are usually of the Jacksonian type, the opening in the skull should be planned so that its centre lies over the area governing the group of muscles in which the seizure begins. As it is often necessary to examine a considerable part of the brain and membranes around this area, the opening in the skull should be a large one.

When there is no external evidence of the original injury, in the form of a cicatrix in the scalp, a depressed fracture, or a gap in the bone, the brain should be exposed by reflecting an osteoplastic flap—Wagner's operation. In doing so, special care must be taken not to injure the dura, which is often firmly adherent to the bone.

If the scalp is adherent to the bone, or if there is a gap in the skull and the dura and scalp are adherent, a large horseshoe-shaped piece is thrown down, so that the adhesions may be separated and the excessive scar



tissue removed, as these are sometimes a cause of fits. The skull is opened by means of a 1-inch trephine, and the opening enlarged as far as may be necessary with rongeur forceps. In cases of depressed fracture the whole of the depressed bone must be removed.

When the original injury has resulted in loss of bone, the gap in the skull is usually filled by dense fibrous tissue, which may be adherent both to the scalp and to the dura mater and through it to the cortex of the brain. Such a cicatricial mass should be dissected away completely and the opening in the skull enlarged with rongeur forceps. After the necessary amount of bone has been removed, the dura is opened, either by a crucial incision or by throwing down a flap.

The further steps of the operation depend upon the nature of the lesion found. An organising blood clot is removed; a traumatic arachnoid cyst is either enucleated entire, or a portion of its wall is dissected away and the cavity drained. Search should be made for any loose spicule of bone which may have been driven into the cortex and become embedded there. An obvious cicatrix in the cortical tissue may be excised, but it is necessarily followed by the formation of a fresh scar. If no visible lesion is discovered, the cortical area governing the muscles in which the fits originate may be excised. The focus to be removed may sometimes be recognised by stimulating the motor cortex with a mild electric current, and so inducing contraction of the group of muscles which gave the "signal symptom" of the fits. The clinical value of this procedure, however, is not great, and Krause says "it should not be employed except for imperative reasons," as it is liable to be attended with not inconsiderable damage in the human subject.

The value of inserting such substances as silver or gold foil or Cargil membrane between the brain and the dura with a view to preventing the formation of fresh

adhesions is doubtful. Kocher does not recommend replacement of the bone after operating for epilepsy.

The patient should abstain from work, especially manual labour, for several years after the operation.

The operation for **Traumatic insanity** is performed on the same lines as for traumatic epilepsy.

**Operation for Compound Fracture of the Skull.**—All varieties of compound fracture of the vault of the skull call for operative treatment to admit of the wound being purified, and depressed or comminuted fragments being dealt with, extravasated blood removed, and bleeding vessels secured. No exploration of the wound by probes or in any other way should be attempted before the patient is anæsthetised.

The scalp is shaved and purified, the edges of the scalp wound, if lacerated or soiled with gross dirt, pared away, and the surface wound thoroughly cleansed by washing with peroxide of hydrogen. The wound in the scalp is enlarged sufficiently to reveal the extent of the injury to the bone.

If nothing more than a *fissure* is found and the patient presents no signs of intracranial injury, the wound is purified and the scalp sutured, a drain being left in for safety.

If a *punctured* fracture is found, the bone around the perforation should be removed by means of a trephine, to ensure that all grossly infected bone is removed, to give free access to the dura mater and brain beneath, so that they may be purified, and to provide an opening for free drainage.

If the bone is *depressed*—gutter or pond fracture—the trephine ( $\frac{1}{2}$  inch) is applied so as to cover the edge of the depression and the adjacent portion of intact skull, the pericranium being first reflected in such a way as will best conserve the vitality of the depressed segments. After the dise is removed an elevator is passed under

the depressed piece of bone, and, using the edge of the intact skull as a fulcrum, this is levered up to its proper level. As the inner table is often splintered, loose fragments must be sought for and removed. To gain access to such loose fragments it may be necessary to enlarge the opening with rongeur forceps. If the dura is torn, it should be opened up to explore the brain, which may have been damaged by splinters of the vitreous table being driven in upon it.

The dura is then sutured, and the scalp wound closed, provision being made for drainage.

If the bone is *comminuted* as well as depressed it may not be necessary to use the trephine. A loose fragment, preferably one from which the pericranium has been separated, is removed, and through the opening thus obtained the elevator is introduced and the remaining fragments are levered into position. If this is not practicable, a circle is removed from the intact portion of skull at a convenient place to admit the elevator. Sometimes a projecting ledge can be removed with a Hey's saw.

The dura and brain having been examined and purified, the pericranium is folded back over the fragments and the wound closed, drainage being provided for.

**Operations for Simple Fractures of the Skull.**—There being no external wound, a horseshoe-shaped flap of scalp is reflected with its base downwards. In other respects the steps of the operation are similar to those for compound fractures.

As the wound is not an infected one it is not usually necessary to provide for drainage.

**Operation for Fracture of the Base of the Skull.**—In a number of cases of basal fracture in which symptoms of compression are prominent, the relief of intracranial tension afforded by opening the skull has been followed by recovery.

The best operation for this purpose is the intermusculo-temporal decompression operation proposed by Harvey Cushing (p. 289). The procedure may be carried out on one or on both sides according to the necessities of the case.

**Operations for Bullet Wounds of the Skull and Brain.—**

The primary object of the operation is to purify the track of the bullet and to elevate any depression or remove any fragments that may have been driven into the brain.

The operation is similar to that performed for punctured fractures. The under surface of the scalp flap should be examined carefully for any loose hairs, portions of head-gear, or other foreign body that may have gained entrance. As the inner table is often shattered over a considerable area it is advisable to enlarge the opening with rongeur forceps sufficiently to enable all splinters to be removed.

The margins of the perforation in the dura mater should be clipped away with scissors, and the opening enlarged so as to give free access to the damaged area of the brain. After all blood clot and disintegrated brain tissue have been washed away with a stream of hot saline solution (115° F.), a search is made for any splinters of bone or other foreign body that may have been driven in.

If there is no exit wound, it must be assumed that the bullet is still within the skull, but if it cannot be seen or felt no prolonged search should be made for it, as its course can never be predicted and much damage may be done by hunting for it.

If, however, there is an elevated fracture of the skull on the side opposite to the wound of entrance, this part of the skull should be exposed and opened with the trephine. In this way the splintered fragments can be removed and the bullet may be found in the vicinity of



the trephine opening. If it is not at once discovered it should not be searched for, as it may have rebounded and buried itself deeply in the brain.

When there is also a wound of exit this must be dealt with in the same way as the entrance wound.

A drainage tube is placed in the subdural space, and brought out through one corner of the flap.

Experience gained in recent warfare shows that the results of these operations are on the whole satisfactory.

**Operations for Intracranial Suppuration. For Extradural Abscess.**—When the abscess is secondary to an *infected fracture of the skull*, the scalp wound is enlarged and any loose fragments of bone removed or depressed fragments elevated. If there is merely a fissure in the bone, a  $\frac{1}{2}$ -inch trephine circle is removed, and the inflamed bone snipped away with rongeur forceps. The pus having been removed, the cavity is lightly packed with iodoform gauze and the wound is treated by the open method.

When the abscess is secondary to *middle ear disease*, the mastoid antrum is first opened up, and the suppurative process traced up by removing all diseased bone with rongeur forceps until the abscess cavity is freely exposed.

When the infection has spread from the *frontal sinus*, the overlying scalp, which is usually œdematous (Pott's puffy tumour), is reflected, a  $\frac{1}{2}$ -inch trephine circle removed, and the opening in the bone enlarged with rongeur forceps sufficiently to give free access to the limits of the abscess. The pus is removed, the cavity purified and drained, and the scalp wound sutured except where the drain emerges.

**For Abscess in the Temporal Lobe.**—A horseshoe-shaped flap of scalp is thrown down so as to expose the temporal fossa just above and behind the external auditory meatus. The centre pin of a 1-inch trephine



is applied at a point in line with the posterior osseous wall of the external meatus, three-quarters of an inch above the posterior root of the zygoma (Macewen) (Fig. 122). The bone at this part is very thin as there is no diploic layer, and care must be taken in removing the disc not to damage the posterior branch of the middle meningeal artery, which ramifies on the surface of the bulging dura mater. A catgut ligature is carried round any prominent vessels in the dura that must to be cut in opening the membrane.

A crucial incision is then made in the dura, or a flap may be thrown up. If the abscess is not at once recognised on the surface, a pair of narrow-bladed sinus forceps or a Horsley's pus evacuator is pushed through the cortex in a direction slightly forwards and inwards parallel with the tegmen tympani, the blades being opened every quarter of an inch (Macewen). If no pus escapes, the instrument is withdrawn and passed in another direction. This may be repeated until every part of the temporal lobe has been explored. The instrument should always be reintroduced at the same point to avoid unnecessary damage to the cortex, and should never be passed in for more than an inch and a half.

When the abscess is tapped the pus is allowed to escape, care being taken that the meningeal space is not infected, and a rubber drain is introduced before the exploring instrument is withdrawn. A small opening is made in the base of the flap for the drain to pass through, and the scalp is sutured back in position.

The firm fibrous wall of a *chronic encapsulated abscess* in the white matter of the centrum ovale may not yield before the exploring instrument, and it may be necessary to use a tenotomy knife passed along the groove of a hernia director to reach the pus.

As temporal abscesses are often multilocular it is

difficult to maintain efficient drainage, and re-accumulation of pus frequently occurs. Krause recommends that the cortical substance be incised sufficiently to expose the wall of the abscess, which is then freely divided, the little finger introduced, and the septa broken down so as to throw all the loculi into the main cavity. As much of the lining wall as possible is removed, and into the resulting cavity a rubber tube is inserted and packed round with iodoform gauze.

**For Cerebellar Abscess.**—The abscess is usually situated in the anterior and lateral portion of the lateral lobe of the cerebellum, and in a proportion of cases it is bilocular, one cavity lying above the other and communicating with it by a narrow channel (Ballance).

The patient is placed in the prone position, his head supported on a suitable rest, and a pillow inserted under the lower ribs. In the event of the breathing becoming embarrassed during the operation, artificial respiration can be carried out by Schäfer's method without changing the position of the patient.

A musculo-cutaneous flap is thrown down, the incision beginning in the middle line about an inch below the external occipital protuberance, passing along the superior curved line of the occipital bone and ending at the apex of the mastoid process. The hæmorrhage from the branches of the occipital artery is pretty free and must be controlled by forceps. If the mastoid emissary vein bleeds, a piece of catgut should be packed into the foramen. A 1-inch trephine circle is removed from the occipital fossa, about an inch and a half behind and half an inch below the external auditory meatus. In this way the lateral sinus is avoided. The bone is very thin here, and care must be taken not to injure the dura.

The dura is opened by a crucial incision or by throwing up a flap, and the cerebellum explored with sinus forceps passed forwards and inwards towards the

posterior border of the petrous bone. Before the exploring instrument is withdrawn a rubber or gauze drain is introduced. The flap is then replaced and sutured in position, a stab opening being made in its base for the passage of the drain.

**Operations for Cephalocele.**—*Congenital Cephalocele.*—

The thin, nævoid, or ulcerated portion of skin over the most prominent part of the cephalocele should be removed by crescentic incisions carried round it. Integumentary flaps which will admit of complete closure are then planned and reflected so as to expose thoroughly the sac and the margins of the aperture in the bone. With a trocar and cannula the cerebro-spinal fluid is withdrawn slowly, to avoid the risk of sudden displacement of the brain and respiratory or cardiac embarrassment.

If the protrusion includes brain matter this should, if possible, be returned to the cranial cavity. If this is impossible, and if the prolapsed portion of brain is not vital to life or functionally important, it may be excised. As this step is often attended with considerable bleeding, and adds materially to the shock of the operation, it should be avoided if possible.

The greater part of the collapsed sac is then removed, enough being preserved, however, to admit of its being closed without the risk of leakage of cerebro-spinal fluid.

The flaps are now sutured in position, and, unless the intracranial part of the operation has been attended with bleeding, drainage is dispensed with.

Attempts have been made to remedy the osseous defect in the skull by transplanting bone and other protective substances, but without much success.

**Operations for Internal Hydrocephalus.**—*Puncture of the lateral ventricle* may be performed under local anæsthesia. A trocar and cannula is passed directly inwards through the outer angle of the anterior fontanelle,

care being taken to avoid the longitudinal sinus, and the instrument must not be pushed in for more than one and a half or two inches. From a half to one ounce of cerebro-spinal fluid is withdrawn, and the puncture is sealed with collodion. This is repeated at intervals of a week.

The descending horn of the lateral ventricle may be tapped by introducing the trocar and cannula through the lateral fontanelle, and passing it in a direction slightly upwards and forwards for about two inches.

When the fontanelles are closed it is necessary to remove a small ( $\frac{1}{4}$ -inch) trephine circle from the skull, either in the frontal or temporal region, before inserting the trocar and cannula. After tapping, the circle of bone is not replaced, so that subsequent punctures may be made through the opening.

Of the various methods of establishing *permanent drainage of the lateral ventricle*, that suggested by Keen is perhaps the best. A horseshoe-shaped flap of the scalp is reflected over the position of either the anterior or the lateral fontanelle. If the fontanelle is still open it is enlarged with rongeur forceps to a diameter of an inch or more; if it is closed, a 1-inch trephine circle is removed. The dura is opened, a large-sized trocar and cannula passed into the ventricle, and a quantity of cerebro-spinal fluid, not exceeding an ounce and a half, allowed to escape slowly. To establish a permanent communication between the cavity of the ventricle and the arachnoid space, one end of a decalcified bone tube is placed in the ventricle and the other end in the space between the dura and the brain, the curve of the tube being adapted to the shape of the brain. To prevent leakage of cerebro-spinal fluid, the dura should be accurately closed.

**Operations for Cerebral Tumours** are described at page 269.

**Operations for Tumour of the Cerebellum.**—If the tumour can be definitely located in one lobe of the cerebellum, the skull is opened in the same way as for abscess (p. 284).

The trephine circle having been removed, the opening is enlarged upwards to the posterior edge of the mastoid process with rongeur forceps until the lateral sinus comes into view, and downwards to the foramen magnum. Krause and J. M. Cotterill lay stress on the importance of removing freely the adjacent margin of the foramen to give more complete access, and to afford more space for the structures at the base and so avoid the risk of pressure on them.

If the intracranial tension is not great and the general condition of the patient permits of delay, the further steps of the operation should be postponed for some days. As the effusion on the surface of the dura in the interval between the two stages of the operation obscures the position of the transverse and occipital sinuses, these should be marked by fine silk sutures passed through the outer layer of the dura. The scalp flap is then replaced and held in position by a few horsehair sutures.

The *second stage*, whether carried out at once or after the lapse of a few days, consists in opening the dura and dealing with the tumour. The dura is thrown down as a flap. If the tumour does not show on the surface of the cerebellum its position may be determined by palpation or by exploratory puncture, but great care must be taken not to damage the friable cerebellar tissue unduly. With the aid of a dissector or spoon the growth is enucleated. The dura mater is then closed and the skin flap sutured in position.

When it is impossible to decide in which lobe the tumour is situated, and in cases in which the growth occupies the *cerebello-pontine angle* (tumours of the



acusticus), it is necessary to open the cerebellar fossa more widely. This may be done by an osteoplastic operation, or with the trephine. Owing to the difficulty of access, the limited field for operating, and the time occupied by the process, the osteoplastic method is not recommended.

An incision is carried down to the bone from the posterior edge of one mastoid process, along the superior curved line of the occiput to a corresponding point on the opposite side, and the flap thus marked out is rapidly reflected and the hæmorrhage controlled by forceps.

A 1-inch trephine circle is then removed from each cerebellar fossa, exposing the dura mater. With a blunt director, the dura with the occipital sinus is separated from the bone between the two trephine openings, and with a Gigli saw the intervening bridge of bone is removed. The scalp flap is then separated downwards sufficiently to expose the posterior edge of the foramen magnum, and with rongeur forceps the ridge of bone between the foramen and the opening in the skull is nibbled away. If the operation is to be performed in two stages the scalp flap is now replaced.

A few days later, the wound is reopened and a vertical incision is made in the dura mater on each side of the occipital sinus from the level of the torcular Herophili to the foramen magnum, and with an aneurysm needle passed through the falx cerebelli a double catgut ligature is passed round the sinus, which is tied at each end.

The space thus afforded enables the cerebellum to be displaced to a considerable extent with the aid of a broad pliable retractor, which can be adjusted to the shape of the cerebellum. All movements must be carried out slowly to admit of the intracranial pressure adjusting itself, and so avoiding disturbance of the cardiac and respiratory centres. The veins that ascend from the upper surface of the cerebellum to the sinuses

in the tentorium cerebelli should be doubly ligated and divided. When the tumour is hard it can usually be enucleated by blunt dissection.

Tumours of the acoustic are as a rule easily separated from the nerve with the aid of a dissector. The space available does not admit of the use of the finger. Any bleeding vessels that cannot be secured and ligated can usually be controlled by gauze pressure.

The flap of dura mater is replaced and stitched, and the external wound closed by suturing the flap in position, provision being made for the exit of the gauze or other drain.

**Cerebral Decompression.**—In cases of cerebral tumour, in which there is no hope of being able to remove the growth, experience has shown that the more distressing symptoms—blindness, headache, and persistent vomiting—can be greatly alleviated by making a large opening in the skull to diminish the intracranial tension. This procedure was first deliberately employed by Thomas Annandale, and has more recently been extended and elaborated, notably by Victor Horsley, Harvey Cushing, and Charles H. Frazier.

The opening is best made over one of the “silent” areas of the brain—for example, in the right temporal region, and to prevent excessive protrusion of the cerebral substance the temporal muscle should be preserved, as recommended by Cushing.

*Cushing's Intermusculo-temporal Operation.*—An integumentary scalp flap is formed from the temporal region by carrying a curved incision from a point below and behind the external angular process, along the line of the temporal crest to end at the root of the zygoma just above the ear (Fig. 127). This flap is reflected downwards as far as the zygoma, exposing the fascia covering the temporal muscle. An oblique incision, carried from the centre of the temporal crest downwards and forwards

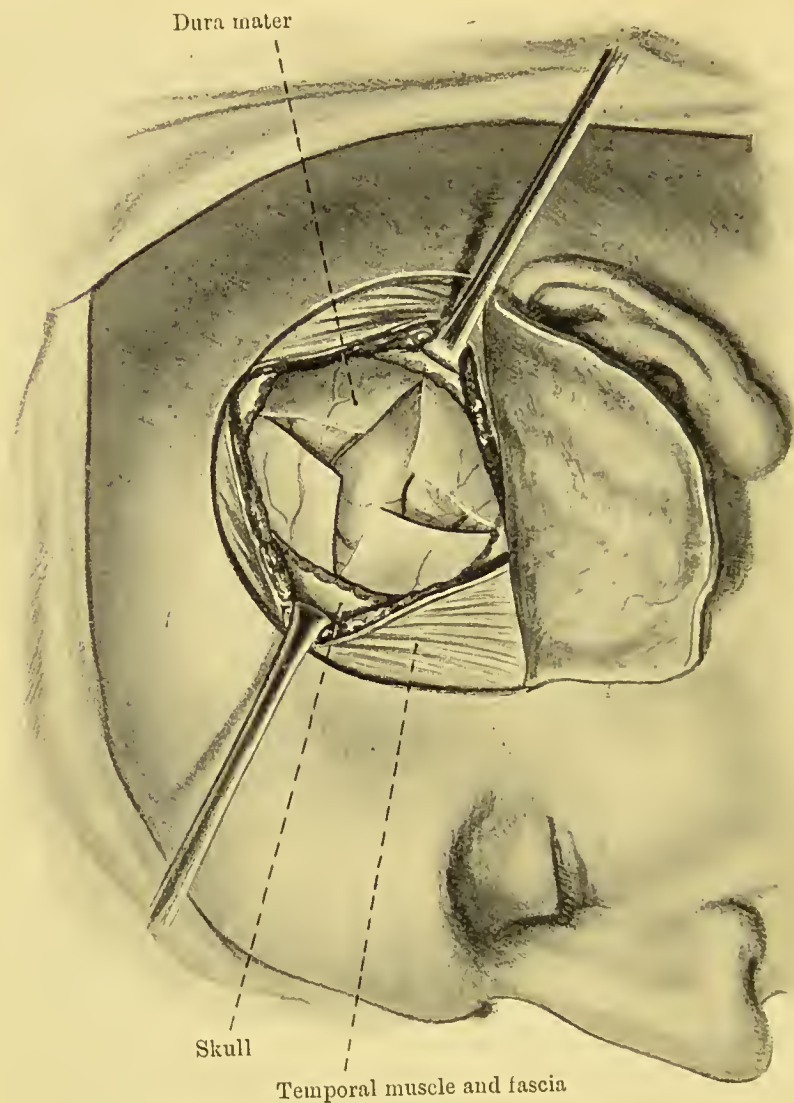


FIG. 127.—Cushing's Intermusculo-temporal Decompression Operation.

to the mid-point of the zygoma, splits the temporal fascia in the line of the fibres of the muscle, which are then separated by blunt dissection until the perieranium is exposed, and this is incised in the same line as the fascia. The muscle is retracted backwards and forwards and the floor of the temporal fossa exposed by separating the perieranium. A  $\frac{3}{4}$ -inch trephine circle is removed,

and the opening in the bone enlarged with rongeur forceps backwards and forwards, until a sufficiently large gap has been made. A crucial incision is then made in the dura mater, care being taken to secure any meningeal vessels by encircling ligatures before they are cut. A small rubber drainage tube may be inserted under the tip of the temporal lobe and brought out through a puncture opening made in the base of the flap.

The split fibres of the temporal muscle and the fascia are then separately approximated by catgut sutures, and the skin flap replaced and sutured in position. The drain may be removed at the end of twenty-four or forty-eight hours.

**Combined Exploratory and Decompression Operation.—**

It frequently happens, after the brain has been exposed by an osteoplastic operation in the hope that a tumour in one of the cerebral hemispheres can be removed, that the growth is found to be irremovable, and it becomes necessary to convert the procedure into a palliative decompression operation. If this is effected by removing the separated area of bone from the flap, the resulting opening is dangerously large and an undue amount of brain tissue is protruded, and if this includes the motor areas contra-lateral paralysis may ensue. Further, the pressure of the hernia on the scalp flap may interfere with union and lead to the formation of a hernia cerebri.

To avoid these dangers, and at the same time to retain the advantage of being able to explore the brain before performing decompression, Harvey Cushing has devised the following procedure.

An osteoplastic flap is formed and reflected as in Wagner's operation. If the tumour is found to be irremovable a semilunar area is removed from the sub-temporal part of the bone flap with rongeur forceps,



and from the corresponding portion of the temporal fossa a similar area is snipped away until a circular gap of appropriate size has been formed in the usual position for a decompression operation. The dura mater is then opened in a stellate fashion opposite this opening, sufficiently to relieve the intracranial tension, and the flap, which now comprises the remainder of the reflected segment of bone, the temporal muscle, and the scalp is replaced and sutured in position. "Thus the advantages of the usual subtemporal decompression can be combined with the more extensive exploration permitted by a temporary osteoplastic resection."

**Removal of the Gasserian (Semilunar) Ganglion.**—The Gasserian ganglion, enclosed in a capsule formed by a splitting of the dura mater, lies in a depression on the anterior aspect of the petrous portion of the temporal bone. The three divisions of the trigeminal nerve spring from its anterior border and pass forward. The first or *ophthalmic division* is a long slender cord which lies in close relationship with the outer wall of the cavernous sinus, and runs horizontally forwards to pass into the orbit through the sphenoidal (superior orbital) fissure.

The second or *superior maxillary division* passes forwards and slightly downwards for a distance of about an inch, to enter the foramen rotundum.

The third or *inferior maxillary (mandibular) division*, shorter and broader than the other branches, passes almost vertically downwards to reach the foramen ovale. It carries the motor fibres of the trigeminal nerve which go to supply the muscles of mastication.

The ganglion has been approached by various routes. Rose (1890), who first removed the ganglion, operated from below, removing the zygoma and coronoid process, ligating the internal maxillary artery, and trephining the base of the skull in front of the foramen ovale. Horsley selected the temporal route, and this method,



which was developed and improved by Hartley and Krause, has been extensively employed. It has more recently been modified by Harvey Cushing, and in

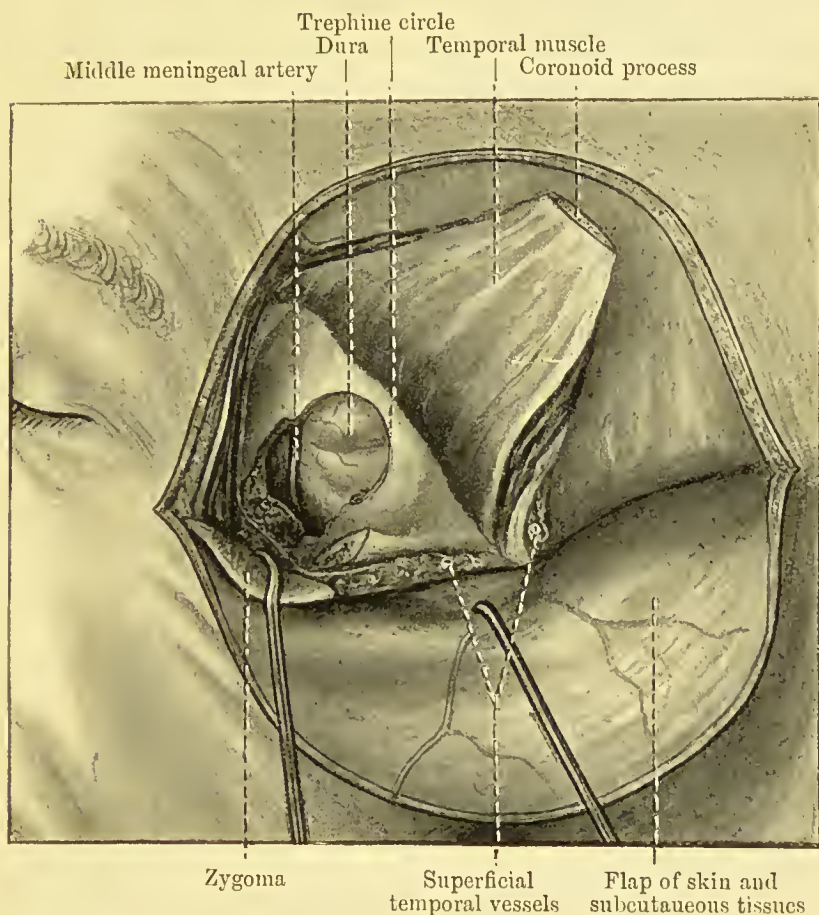


FIG. 128.—Cushing's Operation for Removal of the Gasserian Ganglion, 1st stage.

our experience the procedure of Cushing is to be preferred.

*Cushing's Operation modified.*—The operation we have found most satisfactory is performed as follows.

The patient is placed on the table in a reclining position, with the head as high as is consistent with the

safe administration of the anæsthetic, and resting on a firm sand-bag or other support.

A horseshoe-shaped incision is made through the integument, beginning at a point about two inches behind the external auditory meatus, curving along the line of the temporal ridge, and ending about half an inch below and behind the external angular process (Fig. 128).

The divided branches of the temporal vessels are secured, and the integumentary flap thrown down sufficiently far to expose the zygoma, which is then cleared along its upper border, sawn across at its two extremities, and thrown downwards with the masseter attached to its lower border. The saw lines should be bevelled towards one another, so that when the separated segment is replaced it will not be dragged down by the masseter.

If the zygoma is now pulled downwards and backwards with a hook, the coronoid process of the lower jaw into which the temporal muscle is inserted is exposed. With bone-pliers the coronoid process is snipped off below the temporal insertion, access being facilitated by pushing the lower jaw directly backwards. The temporal muscle is then reflected upwards with the aid of a periosteum separator, and the whole of the temporal fossa is thus freely exposed.

From the lower and anterior part of the fossa a  $\frac{1}{2}$ -to 1-inch trephine circle is removed, and, as the bone here is very thin and is grooved by the middle meningeal artery, care must be taken not to injure the dura mater or the artery.

With rongeur forceps the opening is enlarged downwards and forwards, the bleeding from the diploë, which becomes thicker towards the base, being arrested with Horsley's wax.

When sufficient bone has been removed to give access to the middle fossa, the dura is gently separated from the

bone with the finger, any bleeding that results being arrested by gauze pressure.

If the anterior branch of the middle meningeal, as it

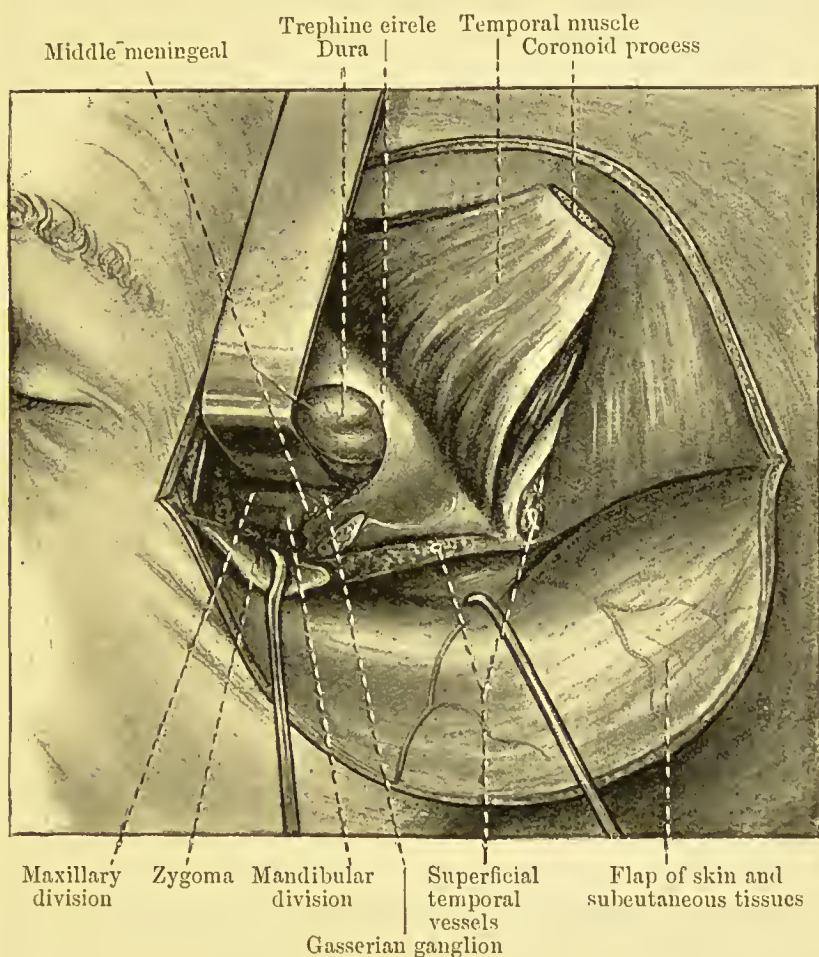


FIG. 129.—Cushing's Operation for Removal of the Gasserian Ganglion, 2nd stage.

runs in the dura, is traced downwards, the main trunk will be reached where it emerges from the foramen spinosum. If the proximal end of the vessel bleeds, a small spicule of bone should be pressed well into the foramen.

A pliable metal spatula, such as Horsley's, is gently passed between the bone and the dura mater, and the temporal lobe raised from the floor of the skull for a distance of about an inch. This causes the middle meningeal artery to stand out in relief, and a double catgut ligature can be passed round it with the aid of an aneurysm needle. After being tied, the vessel is divided between the ligatures, the upper end receding against the dura and the lower end towards the foramen.

If the finger is now pressed firmly against the floor of the skull the mandibular division can be identified and traced to the foramen ovale; similarly, the maxillary division can be traced to the foramen rotundum, and the position of the ophthalmic division can be recognised by feeling the pulsation of the cavernous sinus. With the aid of a strong light directed into the depths of the wound these structures can be seen. The mandibular division is seized close to the foramen with small toothed forceps and cut across; the maxillary division is similarly dealt with, and then by making traction on the two pairs of forceps the ganglion, covered by a thin layer of fibrous tissue, is brought into view.

The sheath is divided with a sharp-pointed tenotome and the ganglion exposed. Not infrequently the dura mater is opened and a small quantity of cerebro-spinal fluid escapes, but this does not impede the operation.

With a probe-pointed tenotome the ganglion is cut across obliquely so as to save the ophthalmic division of the nerve.

The retractor is now withdrawn, and the temporal lobe allowed to subside back into its position, which it does in the course of a few minutes.

The temporal muscle is then folded down and stitched into position; the zygoma is replaced and secured by one or two catgut sutures passed through the periosteum, and the integumentary flap folded up and sutured with



horsehair, a small glass drainage tube being introduced through a special opening made about the centre of the base of the flap.

In our experience this procedure gives better access than the *Hartley-Krause operation* in which the temporal muscle and perieranium are thrown downwards with the integument, and the zygoma is not divided. The displacement of the zygoma admits of the trephine opening being made nearer to the base, and, the temporal muscle being reflected upwards, additional space is provided at the lower part of the wound and the further manipulations are thereby facilitated.

**Operations upon the Hypophysis Cerebri (Pituitary Body).—**By nearly all who have had experience of this operation the intracranial route for reaching the hypophysis has been abandoned in favour of the nasal route.

Halsted's procedure is that which has received most acceptance. High tracheotomy is performed, and the pharynx packed to prevent blood reaching the air-passage. The upper lip is retracted and a horizontal incision made through the mucoperiosteum of the alveolus close to the angle of reflection. The soft parts are raised and the nose displaced upwards. The septum is divided with bone forceps, and displaced upwards and laterally; the turbinates, the vomer, and the perpendicular plate of the ethmoid are removed, and an opening is then made through the anterior wall of the sphenoidal sinus and the cells broken down until the wall of the sella turcica is reached. When this has been chiselled away the growth is exposed, and is removed with a sharp spoon. After being flushed with saline solution the long narrow cavity is packed with iodoform gauze. The septum is then sutured in position and the mucous membrane of the mouth replaced and sutured.

Schlosser and von Eiselsberg expose the nasal cavity



by displacing the nose to the right, an incision being made from the forehead along the left side of the nose, and they remove more bone from the upper lateral aspects of the nasal cavity, including the inner wall of the orbit nearly to the optic foramen, the inner wall of the left maxillary sinus and part of the left nasal process of the superior maxilla.

Cushing recommends a decompression operation only, either by the temporal route, or through the nasal cavity in which case the capsule of the pituitary is incised.

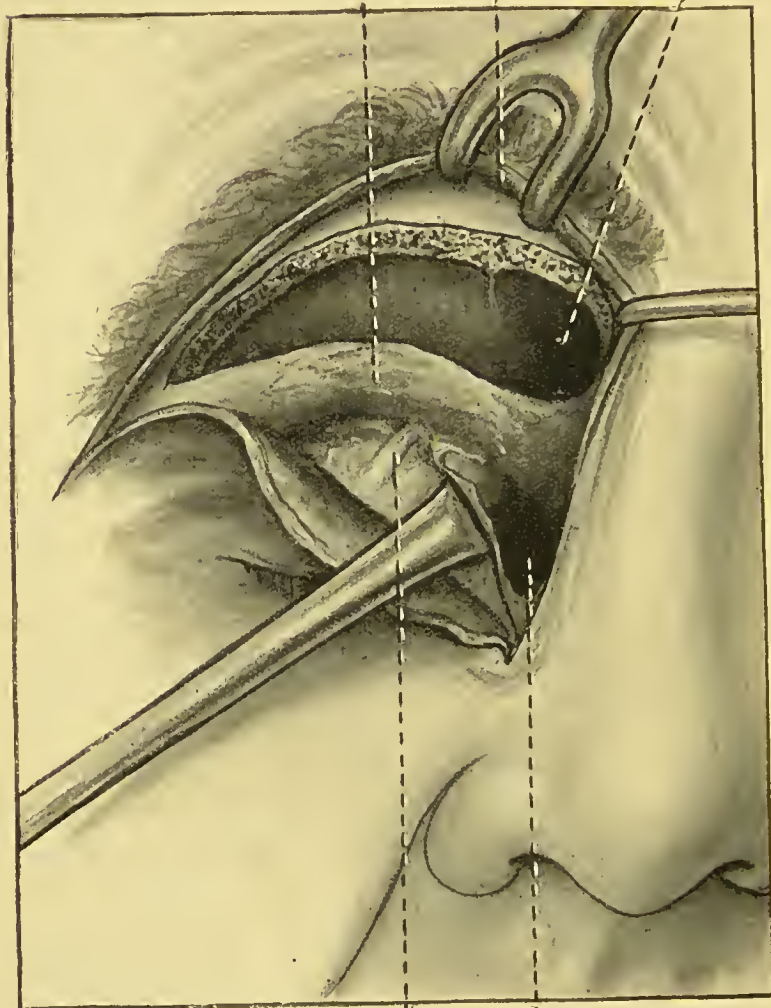
**Operations for Mastoid Disease.**—In operating for the relief of symptoms in acute cases, it is only necessary to open up the mastoid antrum and all the cells, and to establish satisfactory drainage by this route—*Schwarztz's operation*. The middle ear and its contents must not be touched, lest the function of the organ be interfered with.

A curved incision is made over the mastoid about a quarter of an inch behind, and parallel with, the attachment of the auricle. The periosteum is detached and the auricle turned forward until the posterior and superior walls of the osseous meatus are exposed. If a sinus is found it should be enlarged by means of a gouge, as it almost certainly communicates with the antrum. If there is no sinus the gouge should be applied in the *suprameatal triangle* (Fig. 122), which is bounded above by the posterior root of the zygoma, below by the upper and posterior segment of the bony external meatus, and behind by an imaginary line joining these (Macewen). The instrument should be directed forwards and inwards to avoid injuring the sigmoid sinus. If the opening is carried too high the middle fossa of the skull may be opened. The antrum and cells having been freely opened up, the cavity is irrigated and packed with iodoform ganze, which is renewed daily till the discharge ceases and the cavity is filled in by granulations.

When mastoid suppuration is associated with chronic middle-ear disease it is usually necessary to perform the complete radical operation—*Stacke-Schwartz* operation, which consists in throwing the antrum, attic, and middle ear into one cavity. After the mastoid antrum and cells have been fully opened up, the soft parts lining the meatus are detached from the upper and back part of the canal. The Stacke protector or a bent probe is then passed from behind forwards through the aditus, and the posterior wall of the osseous meatus, along with the bridge of bone forming the inner end of this wall, is removed with the chisel. At this stage of the operation care should be taken to avoid injuring the facial nerve, and the anæsthetist should be directed carefully to watch the patient's face and observe whether any twitching occurs. The outer wall of the attic, that is, the inner end of the superior wall of the osseous meatus, should next be removed. The operation is then completed by removing the malleus and incus, if they are still present, the remains of the tympanic membrane, and all granulation tissue. The large cavity thus made in the bone is rendered as smooth as possible, the burr or chisel being applied to all ridges or overhanging edges. The cartilaginous meatus is enlarged by carrying two parallel, horizontal incisions through the soft parts previously detached from the posterior meatal wall. The flap thus formed may be pushed backwards by the gauze or worsted packing that is introduced into the mastoid cavity through the meatus, or stitched to the skin behind the auricle. The posterior skin wound is completely sutured, and the after-dressing is carried on through the meatus. Healing of the mastoid cavity may be hastened by the application of skin grafts, as recommended by Ballance, when granulations have formed.

A modification of this operation is frequently useful in cases of chronic middle-ear suppuration. With the

Flap dissected up with periosteum  
 Bridge of bone covered by periosteum  
 Frontal sinus



Superior oblique tendon      Ethmoidal cells opened up

FIG. 130.—Killian's Operation on the Frontal Sinus.

object of improving the hearing the tympanic membrane and ossicles are left untouched, but with this exception the operation is identical with that just described.

**The Radical Operation on the Frontal Sinus—Killian's Operation (Fig. 130).**—An incision is carried down to

the bone along the upper edge of the orbital margin, and at its inner end is prolonged down the middle of the nasal process of the maxilla. The soft parts are separated, and, with a small trephine or gouge, the sinus is opened above the orbital ridge. A groove is then made with the chisel and mallet immediately above and parallel with the orbital margin, and with rongeur forceps the whole of the anterior wall of the sinus is removed. After the sinus has been cleared out and its mucous membrane scraped away, the floor (orbital wall) of the sinus, the frontal process of the maxilla, and the rest of the floor of the sinus are in turn removed, until the middle turbinal, and the anterior and middle ethmoidal cells are exposed. As these are usually involved in the disease they are removed. A thick rubber drainage tube is passed into the nose, and the wound is closed, except where the upper end of the tube emerges. As the supra-orbital ridge is preserved, the disfigurement is slight.

## CHAPTER XVII

### OPERATIONS ON THE SPINE AND CORD

LAMINECTOMY : *In general ; for traumatic hæmorrhage ; for fracture ; for Pott's disease ; for tumours of cord and membranes ; for resection of posterior nerve roots.* OPERATION FOR SPINA BIFIDA.

#### Operation for Opening the Spinal Canal—Laminectomy.

—This operation, which has for its object the relief of pressure on the spinal cord, is called for in a variety of conditions, such as injuries associated with hæmorrhage or displacement of fragments of bone, tuberculous disease of the vertebræ, tumours of the spine, the cord, or its membranes, and chronic meningitis.

The steps of the first stage of the operation, which consists in laying open the spinal canal and exposing the theca, are the same whatever the nature of the lesion ; the means taken to relieve the excessive pressure vary with its cause.

*Exposure of the Theca.*—The patient is placed in the prone position, precautions being taken that the respiration is not impeded in any way. One firm sand-bag is placed under the pelvis, another supports the upper part of the chest, and a third is placed under the forehead. In this way the abdominal muscles have free play in respiration, the larynx and trachea are not pressed upon, and free access is obtained to the face in administering the anæsthetic. The arms must rest on the table, otherwise by their weight they will interfere with the thoracic movements. To prevent a sudden and excessive escape of cerebro-spinal fluid if the theca is opened, the head



and thorax should be on a lower level than the rest of the body.

The site of the lesion having been localised, a free incision is made to expose the spinous processes of at least five or six vertebræ. The incision may be placed directly over the spinous processes in the middle line, or a rectangular flap of skin and fascia may be raised and folded to one side. As the lesion is often higher than is expected, it is an advantage to be able to extend the wound upwards. With a strong-bladed knife the muscles are separated from the spinous processes and laminae, first on one side and then on the other, the bleeding being arrested by forceps and gauze packing. The muscular masses being held aside with broad retractors, the interspinous ligaments are then divided with seissors, and the spines snapped off at their bases from above downwards with bone-pliers.

The laminae to be divided are then cleared with a periosteum separator or chisel as far as their junctions with the pedicles, the ligamenta subflava divided with seissors, and a suitable saw, such as Macewen's or Horsley's, applied. In using the saw, care must be taken to cut the bone obliquely from without inwards (Fig. 131, *a*); if the section is made vertically (Fig. 131, *b*), it will pass through the pedicle into the body of the vertebra and miss the canal.

If there is difficulty in dividing the bone completely with the saw, the section may be completed with bone-pliers. There is little danger of injuring the theca by

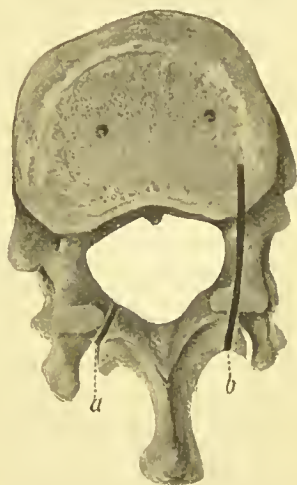


FIG. 131.—Vertebra, to show line in which Saw is directed in Laminectomy.

so doing, as there is usually a considerable space between it and the bone.

In cases of injury, if the bony arches are comminuted, the laminae may be snipped away with rongeur forceps.

*Removal of Cause of Pressure.*—In some *traumatic* cases the posterior aspect of the cord is pressed upon by fragments of the neural arches driven in upon it and by blood extravasated in the extra-dural space, and, to relieve the pressure, it is only necessary to pick out the detached pieces of bone and wash away the clots.

In others, and particularly in cases of fracture-dislocation, the posterior edge of the body of the lower vertebra implicated encroaches upon the canal and exerts pressure on the anterior aspect of the cord. If the displacement cannot be rectified by manipulation the projecting ledge of bone may be chipped off with a chisel, the cord in its theca being gently held aside while this is being done.

Again, a localised collection of blood between the membranes and the cord (*hæmatorrachis*) may be the only cause of pressure. To reach this the theca should be opened in the middle line, and the effused blood washed away with a stream of warm saline solution. Any gross damage to the nervous structures within the theca is beyond the reach of surgical treatment. Clean cut wounds of the nerve roots, particularly the cords of the cauda equina, and even wounds partly dividing the cord itself, should be sutured with fine catgut.

The opening in the theca is sutured with catgut in such a way as to render it watertight, and the wound in the soft parts closed in layers. Even when several arches have been removed it is not necessary to have recourse to osteoplastic operations to replace them, or to employ any mechanical means, such as wiring, to provide support for the spine.

**Operation for Tuberculosis of the Spine.**—In cases of

Pott's disease the pressure is due as a rule to masses of tuberculous granulation tissue and caseated material in the extra-dural space. This is scraped away with a sharp spoon, the opening in the bone being enlarged sufficiently to admit of all diseased tissue being removed. It is usually necessary to hook aside the cord to gain access to the bodies of the vertebræ which are carious and may require to be scraped. The debris having been washed away with a stream of warm saline solution, the wound is closed.

Throughout the procedure great care must be taken not to open the theca, lest the meninges become infected.

**Operation for Tumours.**—Tumours originating in the vertebræ are usually malignant and only lend themselves to partial removal with the sharp spoon, but this may afford marked relief of pressure symptoms. *Extra-dural new growths* are rare, and are easily removed without opening the theca. *Intra-dural tumours* are usually of small size and encapsulated, and, being on one side of the spinal cord between two nerve roots, are easily removed. If one or more *nerve roots* are incorporated in the tumour they must be divided and removed with it. *Intra-medullary growths* can sometimes be enucleated.

After the tumour has been dealt with the theca is sutured and the wound closed. If the bleeding cannot be completely arrested a drain must be introduced.

After laminectomy a large dressing is applied, and unless there is some special reason to the contrary the patient lies in the supine position.

**Resection of the Posterior Nerve Roots—Fœrster's Operation.**—This operation has been chiefly performed to eliminate the spasm in cases of spastic paralysis, particularly those of cerebral origin; to give relief in the gastric crises of tabes; and to abolish pain in the severe neuritis of peripheral nerves which does not yield to

milder measures. An extensive laminectomy is first performed at a level which will give access to the particular nerve roots concerned, the dura is opened, and the selected posterior nerve roots are resected by means of scissors and forceps on one or both sides as may be required. The edges of the dura must be carefully brought together before closing the wound.

**Operation for Spina Bifida.**—*Excision of the Sac.*—The child is placed on the table with the head low to prevent any sudden escape of cerebro-spinal fluid when the theca is opened, and to minimise the amount of fluid lost.

Two curved incisions are made over the most prominent part of the swelling, so as to include the area of thin skin, which is usually adherent to the sac. The integument on each side is then raised sufficiently to admit of the sac being isolated, care being taken to avoid opening the sac.

In the case of a meningocele with a narrow neck, a catgut suture is secured round the neck of the sac, the redundant portion of theca removed, and the skin flaps sutured over the stump.

When the neck is too wide to be securely ligated, the sac must be opened, care being taken to prevent a sudden escape of cerebro-spinal fluid. If, as is usually the case, some of the spinal nerves are prolapsed and spread out over the inner aspect of the sac, these must be separated and returned to the spinal canal before the sac is excised. If the nerves are so firmly adherent to the sac that there is danger of dividing them in effecting the separation, it is safer to return a portion of the adherent sac with the nerves than to persist in the attempt to isolate them. In removing the redundant portion of the sac, a sufficient amount should be left to admit of the opening being made watertight by one or more continuous catgut sutures introduced with a round intestinal needle.

In suitable cases an attempt may be made to strengthen the line of suture by drawing in flaps of muscle or aponeurosis from each side, or to bridge the gap in the bones by separating the adjacent laminae as far out as possible and bringing them towards the middle line.

The operation is completed by closing the skin wound. To diminish the risk of leakage of cerebro-spinal fluid, and to facilitate union, the patient should be kept in the prone position till the wound has healed.



## CHAPTER XVIII

### OPERATIONS ON THE FACE

OPERATIONS FOR HARE-LIP : *Single ; Double.* FOR CLEFT PALATE.  
FOR EPITHELIOMA OF LIP WITH REMOVAL OF GLANDS

#### OPERATIONS FOR HARE-LIP

THE operation selected will depend upon the size and disposition of the cleft, the extent to which the nose is flattened, and the amount of tissue available to fill the gap in the lip.

To obtain a satisfactory result it is essential that the raw surfaces should be made as broad as possible, that they be brought together without tension, and that a slight projection be left at the free margin to form a papilla or prolabium. To correct the flattening of the nose, it is also necessary that the mucous membrane of the cheek be freely separated from the alveolus.

The bleeding can be controlled by an assistant grasping the lip between his finger and thumb at each angle of the mouth so as to compress the coronary (superior labial) arteries. It is seldom necessary to ligate more than one vessel on each side.

**Operations for Single Hare-Lip.**—*Nélaton's Operation.*—This procedure is suitable for cases in which there is merely a notch at the free margin of the lip and the nostril is not flattened. The apex of the notch is seized with a fine pair of toothed forceps and the tissues put slightly on the stretch, and a  $\Lambda$ -shaped incision is carried

through the substance of the lip around the notch, but without dividing the free edge of the lip (Fig. 132). If

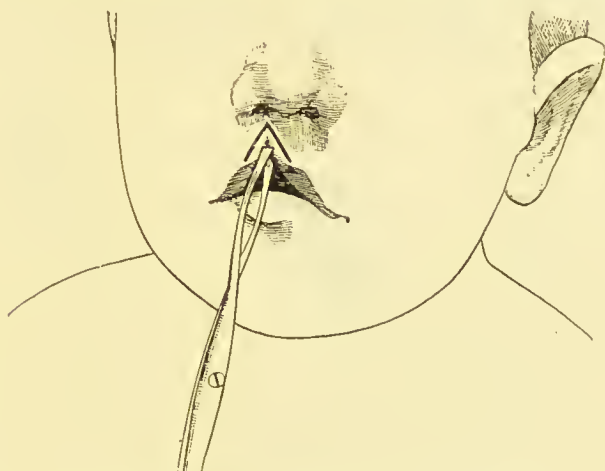


FIG. 132.—Nélaton's Operation, 1st stage.

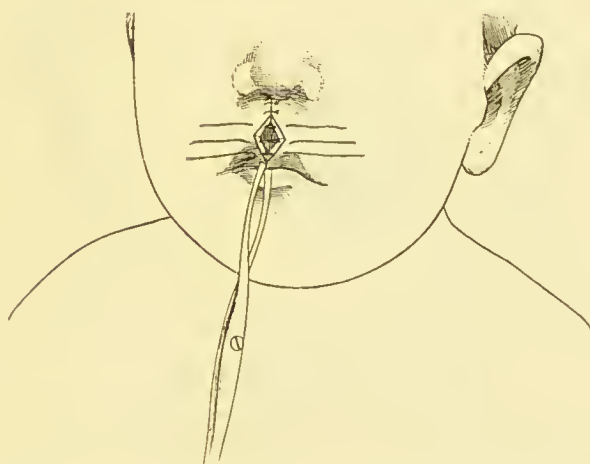


FIG. 133.—Nélaton's Operation, 2nd stage.

further traction is now made on the forceps the incision in the lip becomes  $\diamond$  or lozenge-shaped, and is sutured in the vertical axis (Fig. 133). At first the projection on the free edge may be excessive, but in time it shrinks and leaves a slight papilla.

An alternative plan is to pare the margin of the notch by *two concave incisions* passing out through the free edge on each side (Figs. 134, 135). When the raw surfaces are brought together a vertical scar is left and



FIG. 134.—Edges of Cleft pared by Concave Incisions.

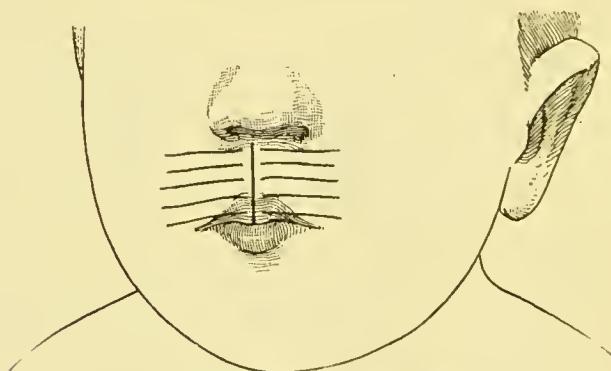


FIG. 135.—Sutures Introduced.

the slight redundancy of tissue on the free edge provides a projecting papilla.

*Rose's Operation.*—This operation is suitable for cases in which the notch extends into the nostril. As the nose is usually flattened it is necessary to begin by separating the lip from the alveolus on the outer side of the cleft. In doing this the knife or scissors should be kept close to the bone, and it may be necessary to

carry the separation as far as the infra-orbital foramen, or even to separate the ala by making an incision around the nostril. The edges of the cleft are then pared by crescentic incisions till the mucocutaneous junction is



FIG. 136.—Rose's Operation, Incisions.

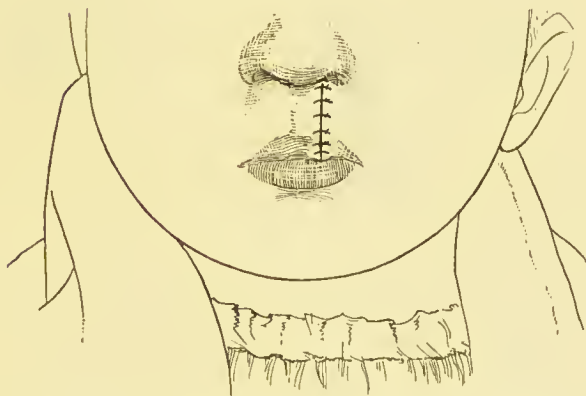


FIG. 137.—Rose's Operation, Sutures introduced.

reached, when a small flap is made on each side at the free margin, and these when folded down form the papilla (Figs. 136, 137).

*Mirault's Operation.*—When the gap is wide and the edges asymmetrical (Fig. 138), the longer and more oblique edge is pared in a straight line, and from the

shorter and more vertical edge a good thick flap is cut with its base left attached at the lower red border of the lip. This flap is then turned down and brought across to the rawed surface on the opposite edge and

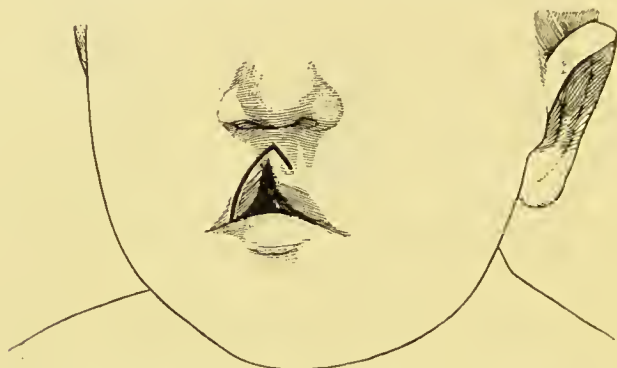


FIG. 138.—Mirault's Operation, 1st stage.



FIG. 139.—Mirault's Operation, 2nd stage.

stitched in position, and the remainder of the wound closed with sutures.

*John Duncan's Operation.*—When, in forming the raw surfaces, it is desirable to avoid sacrificing tissue by paring the edges of the cleft, the method suggested by John Duncan may be advantageously employed. It consists in splitting the lip along the line of junction of skin and mucous membrane, so that two flaps of tissue



are formed ; an outer flap consisting of skin and an inner of mucous membrane.

A narrow-bladed knife is inserted at the apex of the cleft for a distance of about a quarter of an inch, and is carried along the line of the mucéo-cutaneous junction to within a quarter of an inch of the red margin of the lip. At this point the lip is transfixed and cut so as to form on each side a small flap consisting of the whole thickness of the lip.

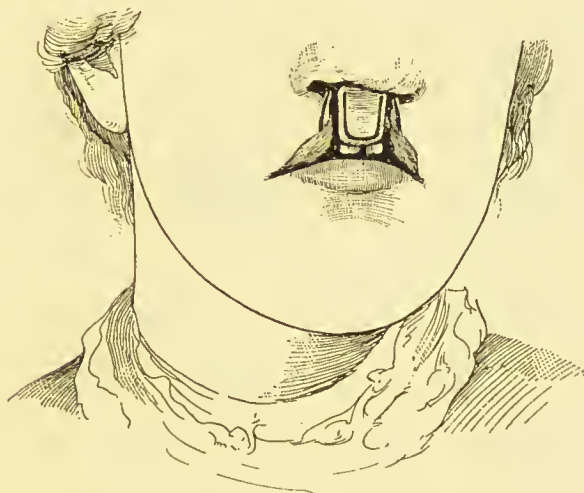


FIG. 140.—Operation for Double Hare-lip, 1st stage.

The mucous flaps are folded inwards and united with a row of catgut sutures, carried sufficiently deeply to bring the raw surfaces on each side into apposition. The cutaneous flaps are then folded outwards and united with horsehair sutures. The two small tags at the lower end of the cleft are folded down and united so as to form a papilla.

**Operations for Double Hare-lip.**—In operating for double hare-lip the procedure adopted is influenced by the size, shape, and position of the os incisivum and prolabium. An attempt should always be made to save as much as possible of these structures.

When the *os ineisivum* retains its normal position, the prolabium is separated from the periosteum, and its edges are pared in a rectangular V- or Y-shaped fashion according to circumstances, so that it may form the central part of the new lip. The outer edges are then pared in a crescentic manner (Fig. 140) or by straight incisions, two short thick flaps being formed at the lower end of each cleft to form a papilla (Fig. 141). To overcome the flattening of the nose, and to admit of the parts



FIG. 141.—Operation for Double Hare-lip, 2nd stage.

being brought together without tension, the mucous membrane of the lip must be freely separated from the jaw, and it may even be necessary to carry an incision round each ala of the nose to effect this. The lower parts of the outer margins of the clefts are then brought together in the middle line and accurately sutured with horsehair, after which the remaining raw surfaces are approximated. To relax the tension on the superficial sutures, two or three silkworm gut sutures are introduced about a quarter of an inch outside the raw surface of one lateral segment, and are carried through the central segment and then out through the opposite

lateral segment. No attempt should be made to bring the prolabium down to the free margin of the new lip, as this tends to depress the tip of the nose.

*When the os incisivum projects* in front of the lateral portions of the maxillary arch it should be broken across and replaced in position after the prolabium has been raised from it. If the base is narrow this can usually be done with the finger and thumb or with a pair of sequester forceps, the blades of which are protected with rubber tubing. It may require to be fixed in its position between the maxillæ by one or two chromic gut sutures. It may even be necessary to chip off the edges of the maxillæ with a chisel to make a bed for the premaxillary segment. Frequently replacement is prevented, or the bone is forced out of position again by the cartilaginous vomer, in which case a V-shaped segment of the septum of the nose should be removed after the muco-periosteum has been separated from the portion to be removed. The prolabium and the margins of the cleft are then dealt with as already described.

*When the os incisivum is attached to the tip of the nose*, or is so deformed that it cannot be utilised to fill the gap between the maxillæ, the bone should be shelled out of the periosteum and the latter sutured into position, after which the soft parts are pared and sutured.

## OPERATIONS FOR CLEFT PALATE

The operation of Langenbeck is that usually employed for complete cleft palate. The patient is placed on the table with the chest raised, and the head slightly dependent, in order that blood and mucus may gravitate readily towards the back of the pharynx. To enable the soft parts covering the hard palate to be brought together in the middle line, it is necessary to separate them from the bone in the form of a muco-periosteal

flap. This is done by carrying an incision down to the bone from the level of the last molar tooth to the level of the lateral incisor tooth, about a quarter of an inch internal to the alveolar edge. This incision passes external to the posterior palatine artery and stops short of the anterior palatine. In this way bleeding is avoided, and the vascular supply of the flap is preserved. The flap is then separated from the bone by means of an elevator sufficiently freely to allow of the edges of the cleft being approximated without tension. It is often necessary to carry the lateral incision backwards into the anterior pillar of the fauces, to divide the palatal aponeurosis and the levator palati in the region of the hamular process. In paring the edges, the uvula is held with each forceps, the edge made taut, and a narrow shaving removed by means of a bistoury; by beveling the edges at the expense of the buccal surface more accurate apposition is obtained, and the tendency to inversion of the margins when the sutures are tightened is obviated. The connections with the septum of the nose are divided with curved scissors.

After paring both edges in this way, interrupted sutures of silver wire, silk, or horsehair are introduced, and to take the strain off the sutures, a thin strip of aluminium may be passed so as to include the two flaps and hold them together. We have found Wolff's plan of performing *the operation in two stages* advantageous: the flaps are pared and separated at the first sitting, and four or five days later the sutures are introduced.

An alternative method of closing the palatal cleft, introduced by Davies-Colley and modified by Arbuthnot Lane, consists in raising the soft parts from the palate and adjacent alveolus in the form of flaps, which are folded across the cleft in such a way that their raw surfaces are opposed to one another. Brophy of Chicago recommends that the palate should be closed in early

infaney, by paring the edges and then forcibly thrusting the maxillæ towards the middle line by digital pressure if possible, or by raising the cheek from off the bone and passing stout silver wire sutures round the palatal processes, and through the maxillæ across the cleft. This operation is attended with considerable shock and has been known to prove fatal.

**Operations for Epithelioma of Lower Lip.**—*Removal of the Growth.*—In the early stage of the disease, when the growth is represented by a small horny swelling on the mucous membrane midway between the middle line and the angle of the mouth, it may be removed by excising a V-shaped portion of the lip, cutting at least half an inch wide of the growth all round. After the coronary vessels have been secured the edges of the wound are brought together, the mucous membrane being stitched with catgut and the skin with horsehair sutures.

When the growth has extended towards the angle of the mouth and has invaded the cutaneous part of the lip, the incisions must be carried sufficiently wide of the disease to include the lymph channels leading to the submental and submaxillary glands, and provision must be made to replace the lower lip by flaps taken from the cheek or neck. An operation on the lines of that devised by Syme meets these conditions in most cases. An incision is carried outwards through the cheek from each angle of the mouth. The growth is then surrounded by two incisions carried from the lateral incisions to meet at the most prominent part of the chin, and the lower lip is dissected off the bone and removed. To fill the gap thus formed two flaps are cut from the submaxillary regions by carrying a curved incision on each side from the apex of the gap downwards and outwards over the margin of the jaw as far as the hyoid bone and then upwards towards the angle of the jaw. These flaps are dissected up,



brought together in the middle line, and sutured to one another and to the central portion of the chin, which has been left undisturbed and serves to give them a fixed basis of support. There is no difficulty in covering the raw surfaces in the neck, as the skin and platysma can be mobilised by under-cutting, if necessary, as far down as the clavicle (Morestin). A tube is inserted through the skin at the lowest level to which it has been undermined.

The incisions must be modified to suit the requirements of the individual case. When, for example, as frequently happens, the growth has invaded the angle of the mouth and spread to the upper lip, an additional V-shaped incision must be carried through the cheek as far as the prominence of the superior maxilla.

*Removal of the Lymph Glands.*—The submental and submaxillary glands into which all the lymphatics of the lip drain should be removed in all cases, whether they are palpably enlarged or not. As the lymphatic vessels intercommunicate freely, it is necessary to remove the glands on both sides.

A collar incision is made about an inch and a half below the lower jaw and parallel with it from the anterior border of the sterno-mastoid on one side to the corresponding point on the other side. This incision falls in the natural fold of the skin and avoids the lower branches of the facial nerve. After the skin and platysma have been reflected the dissection is carried outwards from the middle line, first on one side and then on the other, and the submental glands, which lie between the anterior bellies of the digastric muscles, and the submaxillary glands are removed. It is necessary to take away the submaxillary salivary glands to ensure complete removal of all the lymphatics. If the deep cervical glands are implicated, as they may be in advanced cases, the incision is carried downwards to give access to them.

Care must be taken not to injure the hypoglossal nerve as it runs to reach the tongue beneath the anterior belly of the digastric. Drainage is provided for by making a puncture at the most dependent part of the flap on each side, and the main wound closed by sutures.



## CHAPTER XIX

### OPERATIONS ON THE PHARYNX AND ŒSOPHAGUS

Sub-hyoid Pharyngotomy; Medio-lateral Pharyngectomy. Operation for Naso-pharyngeal Tumour. Removal of Tonsils: *With volsellum and knife; enucleation; with guillotine.* For Tumours of Tonsil. Œsophagotomy; Œsophagectomy. Operation for Diverticulum of Œsophagus.

### OPERATIONS ON THE PHARYNX

**Operations through the Mouth.**—Good access can be obtained to the upper part of the pharynx by a transverse incision through the cheek, extending backwards from the angle of the mouth as far as the masseter muscle and parallel with the branches of the facial nerve (Roscr). There is comparatively little bleeding and the resulting disfigurement is negligible.

Kocher prefers a mesial incision through the lower lip, jaw, and floor of the mouth. The dissection must be made exactly in the middle line between the genio-hyoid and the genio-hyoglossus muscles. The two halves of the jaw are widely separated, and after the intra-buccal operation is completed the jaw is sutured with silver wire.

**Sub-hyoid Pharyngotomy.**—To reach the lower part of the pharynx a transverse sub-hyoid incision is to be preferred.

This operation, which consists in opening the pharynx through the thyro-hyoid membrane, gives access to the

upper aperture of the larynx with the least possible injury to adjacent structures or disturbance of function.

The incision is made along the hyoid bone from one greater cornu to the other, dividing the skin and platysma and exposing the bone. After the superficial veins have been secured, the muscles attached to the lower border of the hyoid—sterno-hyoids, thyro-hyoids, and omo-hyoids—are divided near the bone, and then the thyro-hyoid membrane and the mucous membrane are similarly divided transversely. Care must be taken not to injure the sensory nerve of the larynx, the superior laryngeal, which pierces the lateral part of the membrane. The epiglottis is hooked forwards, and the entrance to the larynx and the cavity of the pharynx inspected.

The lesion is then dealt with, a new growth being removed with the scissors or thermo-cautery, or a tuberculous focus excised or scraped as may be necessary. To obviate the risk of œdema of the glottis, laryngotomy is performed, after which the sub-hyoid wound is packed with iodoform gauze.

**Medio-lateral Pharyngectomy.**—This operation is performed when a carcinoma of the pharynx is situated laterally, and involves the vicinity of the pyriform sinus, the arytenoid cartilage, and the pharynx behind the cricoid. Kocher recommends that preliminary tracheotomy and gastrostomy should be performed. The transverse hyoid incision extends farther towards the affected side, and in addition a vertical mesial incision is carried down as far as the isthmus of the thyroid gland. The depressors of the hyoid are divided more freely on the affected side, and the thyro-hyoid membrane is incised both laterally and vertically.

The upper limits of the disease having been defined, the mucous membrane between the larynx and pharynx is divided clear of the growth, and the thyroid cartilage

incised. A finger is then passed into the pharynx to determine the lower limit of the disease, and the growth is removed.

**Operation for Naso-Pharyngeal Tumour.**—In the removal of a naso-pharyngeal tumour the three main considerations are: to obtain free access, to avoid excessive loss of blood, and to prevent aspiration of blood and mucus into the air passages.

The risk of aspiration is diminished if the patient is placed on the table with the head and upper part of the trunk dependent, but if the growth is large and vascular, preliminary laryngotomy is better, as it admits of the pharynx being plugged. To minimise bleeding, a temporary ligature may be applied to the external carotid artery, on one or on both sides.

Various procedures have been adopted to afford access to the growth. *Nelaton's operation* consists in splitting the uvula and soft palate in the middle line, reflecting the muco-periosteum from the posterior half of the hard palate, and resecting the exposed parts of the palatal process and a portion of the nasal septum. After the tumour has been removed, the muco-periosteum and the soft palate are sutured. This procedure, while it avoids an external scar, does not furnish sufficient room to deal with an extensive growth.

*Rouge's operation* (1873) also avoids a scar on the face, but does not provide much additional room. The upper lip is raised, and the mucous membrane along its line of reflection is divided from the level of the bicuspid teeth on one side to a corresponding point on the other. The cartilaginous septum and the alar cartilages are then separated from the maxilla, and the soft parts divided sufficiently to admit of the upper lip and nose being reflected upwards. After the intra-nasal stage of the operation has been completed, the parts are replaced. Annandale (1889) extended Rouge's operation by split-



ting the alveolus, the palatal process, and if necessary the soft palate, in the middle line, dividing the bony septum, and forcing apart the two maxillæ. The soft palate is subsequently stitched, and the maxillæ fixed in position by a wire suture passed through the alveolar process.

We have obtained good access by splitting the upper lip, separating the alveolar process from the rest of the maxilla by means of a chisel, then dividing the alveolar process and hard palate in the middle line, and holding the two halves aside.

Langenbeck's plan of resecting the greater part of the maxilla gives rise to a considerable amount of disfigurement, but this can be diminished by preserving the orbital plate and the muco-periosteum of the hard palate.

**Removal of the Tonsils.**—*Removal with Volsellum and Knife.*—The parts having been painted with a 5 per cent. solution of cocain, the tonsil is seized with volsellum forceps, pulled out from between the pillars of the fauces, and shaved off with a curved probe-pointed bistoury. The part of the blade near the handle should be guarded by means of a piece of rubber tubing or by wrapping adhesive plaster round it, to avoid injuring the lips or tongue.

*Enucleation.*—This operation is specially applicable to "submerged" tonsils, that is, those which do not project prominently between the pillars of the fauces. In adults it can be performed under local anæsthesia, the oro-pharynx being sprayed with 10 per cent. cocain, and the submucous tissue injected with a 5 per cent. solution of cocain to which a few drops of adrenalin have been added. In children a general anæsthetic is necessary.

The tonsil is grasped by the volsellum and pulled towards the mouth (Fig. 142), and with probe-pointed scissors the mucous membrane is snipped through, beginning at the plica triangularis just internal to the

anterior pillar and passing upwards and backwards in the arch between the two pillars. The finger is then inserted under the mucous membrane, and, working from above downwards, the tonsil in its capsule is shelled from the superior constrictor muscle until only its lower part, at which the vessels enter, remains attached. If strong inward traction with the volsella is now made, the hilum is exposed, and can be divided with the scissors or knife (J. S. Fraser).

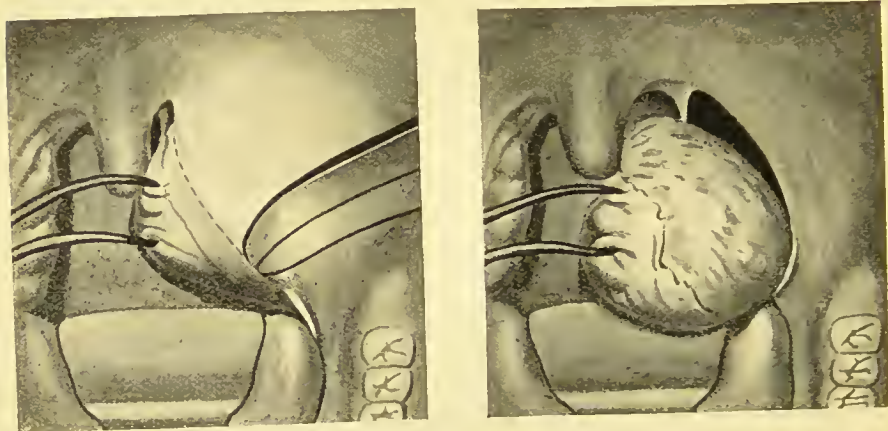


FIG. 142.—Enucleation of Tonsil.

(Lent by Dr. J. S. Fraser.)

The *guillotine operation* is best adapted to cases of simple chronic hypertrophy in which the tonsils are pedunculated. The projecting portion of the tonsil, having been encircled by the ring of the guillotine, is shaved off. A modification of the guillotine operation is that in which a volsella is passed through the ring of the guillotine and the tonsil is grasped, and, as far as possible, drawn through the ring before the knife is pushed home (St. Clair Thomson).

**Operation for Tumours of the Tonsil.**—A growth limited to the tonsil may be reached by making a transverse incision through the cheek; but if the

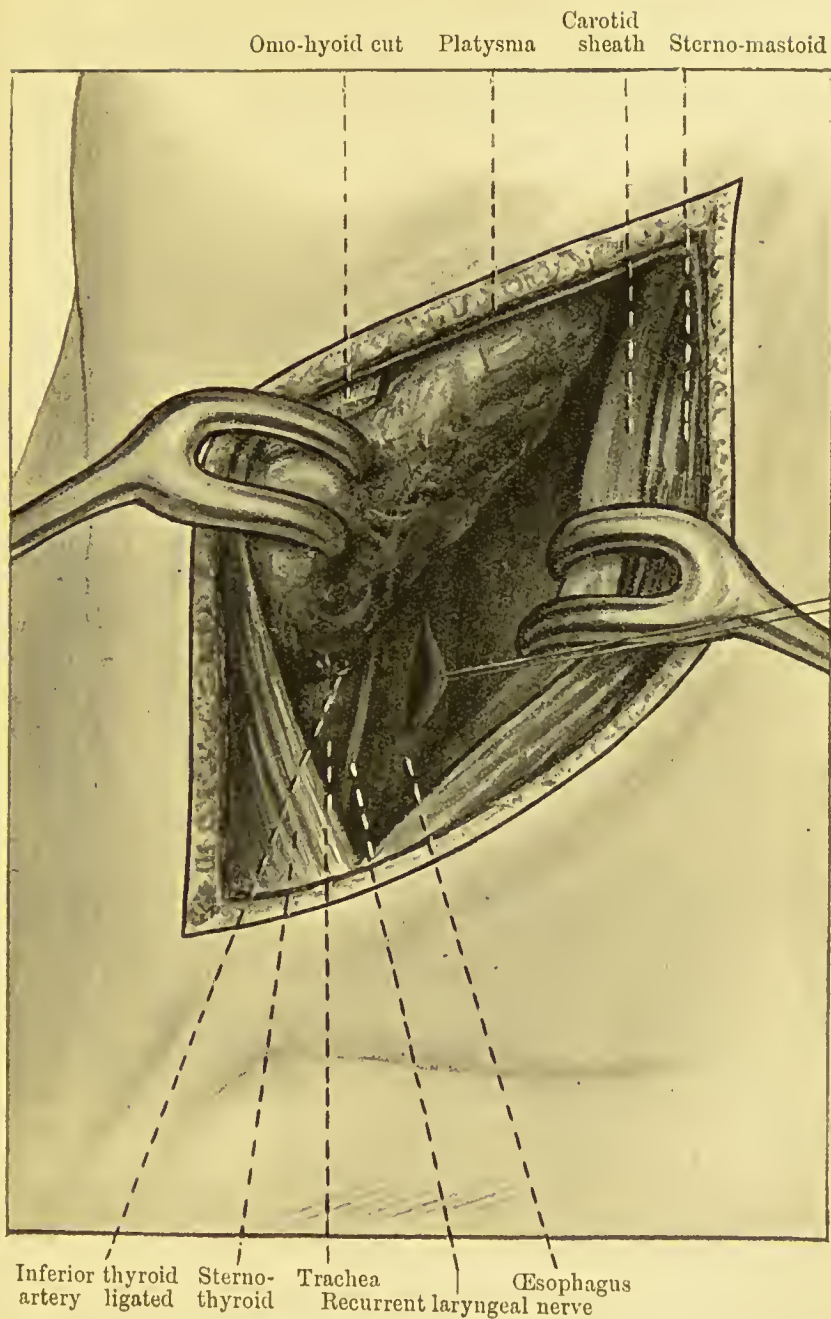


FIG. 143.—Operation of Œsophagotomy.

disease has spread to the side of the tongue, the floor of the mouth, or the soft palate, the lower lip and jaw should be split in the middle line.

The tongue is transfixed with a strand of silkworm gut and pulled well out of the mouth, and the growth removed with scissors or the thermo-cautery. The mucous membrane is first divided clear of the disease, and the growth is detached from the deeper structures. If the tumour is then pulled well forward, the pedicle which contains the vessels can be ligated before being divided.

#### OPERATIONS ON THE ŒSOPHAGUS

**Œsophagotomy** (Fig. 143).—An incision is made along the anterior border of the left sterno-mastoid, from the level of the hyoid bone to a point about a finger's breadth above the clavicle. The skin and platysma are incised, and the external layer of the cervical fascia divided so that the space between the depressors of the hyoid bone and the sterno-mastoid may be defined. The depressors are retracted inwards, the sterno-mastoid outwards, and the omo-hyoid is divided. To enable the carotid sheath to be exposed, it is necessary to divide the process of the deep cervical fascia which connects it to the outer capsule of the thyroid gland. This having been done, the thyroid and trachea are drawn inwards, and the carotid sheath and the descendens hypoglossi nerve outwards. The inferior thyroid artery, which crosses the œsophagus, is then secured between ligatures and divided.

At this stage a bougie should be passed into the œsophagus through the mouth, to distend the tube so that it may be opened easily and safely. The opening is made in the long axis of the œsophagus, rather towards its postero-lateral aspect, to avoid the recurrent



laryngeal nerve, which on the left side lies in front of the œsophagus.

When the operation has been performed for the removal of a foreign body the opening is closed with catgut sutures, and before the external wound is closed a drainage tube is inserted down to the suture line as a safeguard against subsequent leakage.

When the object of the operation is to provide a means of feeding the patient—for example, in cancer of the pharynx or upper part of the œsophagus—a soft œsophageal tube is introduced through the wound and fixed in position, the external wound being packed with iodoform gauze.

**Œsophagectomy.**—Excision may be performed for cancer involving the portion of the œsophagus between the cricoid cartilage and the level of the episternal notch. Kocher considers tracheotomy and gastrostomy necessary preliminaries to œsophagectomy.

When the disease is limited to the upper part of the œsophagus, the longitudinal incision made for œsophagotomy suffices; when it extends farther down, Kocher's collar incision gives good access.

After being exposed the left lobe of the thyroid is turned over to the right, and the upper and lower limits of the growth in the œsophagus are defined. The œsophagus is then freed below the growth, the recurrent laryngeal nerve being separated and held aside. The junction of the pharynx with the œsophagus is next freed by dividing the inferior constrictors, and the portion implicated in the growth is separated from the vertebræ and from the trachea. An incision is then made in the long axis of the œsophagus well below the disease, and after a stomach tube has been inserted and firmly tied into the opening the œsophagus is cut across. A ligature is applied above the growth, the pharynx divided, and the affected portion removed. The stomach



tube is left in position, and the cavity packed with iodoform gauze.

If it is necessary to remove a portion of the trachea it is advisable to cut the trachea across at once and stitch it to the skin (Kocher).

**Operation for Diverticulum of the Œsophagus.**—The site and size of the diverticulum having been previously determined by means of an X-ray photograph taken after a bismuth meal, or by Plummer's threaded probang, the diverticulum is emptied before the anæsthetic is administered, to avoid the risk of its contents regurgitating and being aspirated into the air passages during the operation.

An incision is made along the anterior border of the left sterno-mastoid, the deep fascia is divided, the sterno-mastoid pulled outwards and the depressor muscles inward. The left lobe of the thyroid is raised and the inferior thyroid vein ligated and divided. With the aid of a rigid bougie passed through the mouth the pouch can be identified. It is pulled into the wound, care being taken to avoid the recurrent laryngeal nerve, and opened in order that its interior may be explored. Its neck having been defined, the diverticulum is removed with scissors and the stump closed by superimposed rows of sutures of the Czerny-Lembert type. A drainage tube is passed down to the suture line, and the external wound closed.

## CHAPTER XX

### OPERATIONS ON THE JAWS

OPERATIONS FOR TUBERCULOUS OSTEOMYELITIS: *Of Upper Jaw; Of Lower Jaw.* OPERATIONS FOR TUMOUR OF ALVEOLAR PROCESS. EPULIS. RESECTION OF UPPER JAW. RESECTION OF LOWER JAW: *Of Symphysis and Horizontal Ramus; Of one half of Lower Jaw; Of Ascending Ramus alone.* RESECTION OF CONDYLE OF LOWER JAW: *Excision of Meniscus.* OPERATION FOR FIXATION OF LOWER JAW.

**Operations for Tuberculous Osteomyelitis.**—In planning an operation for tuberculous disease of the *upper jaw*, which usually affects the orbital margin in the region of the malar bone, care must be taken to make the incision parallel with the branches of the faeial nerve and in one of the natural folds of the face. A suitable incision is one beginning a little below the middle of the infra-orbital margin, and passing obliquely downwards and outwards over the malar bone. The infra-orbital vessels and nerve are below the incision. The periosteum is raised from the bone and the diseased focus removed with the gouge or sharp spoon. If the maxillary sinus is opened, as is often necessary, its interior should be smeared with sublimated iodoform-bismuth paste and a packing of iodoform gauze introduced before the wound is sutured.

*In the lower jaw* the diseased bone should be resected subperiosteally so that it may be re-formed.

When the disease is limited to the *ramus* an incision is made from the level of the lower edge of

the lobule of the ear downwards along the posterior margin of the ramus, round the angle and forwards in the submaxillary region as far as may be necessary. To avoid the facial nerve the vertical portion of the incision is only carried through the skin, the remainder goes down to bone. The periosteum together with the muscles—masseter on the outer aspect and internal pterygoid on the inner aspect—is raised and the bone divided in front of the diseased part with a Gigli saw or bone-pliers. If the angle of the jaw is then grasped with lion forceps and twisted, the ramus, including the coronoid process and condyle, can be wrenched out subperiosteally without opening into the mouth. The hæmorrhage having been arrested, the wound is closed, provision being made for drainage.

When the disease involves the *body*, the incision is made below the margin of the jaw, the periosteum is separated from the bone, and the buccal cavity is opened into by separating the gum. With a Gigli saw the bone is divided behind and in front of the diseased area. The opening into the mouth should be closed as far as possible with catgut stitches before the external wound is sutured. To maintain the integrity of the mandibular arch, a piece of bone or ivory may be introduced into the gap.

When it is necessary to remove the *symphysis*, a silkworm suture is passed through the tongue to prevent its falling back and blocking the pharynx.

#### **Operation for Tumour of the Alveolar Process.—Epulis.—**

A tooth having been extracted on each side of the tumour, an incision is made through the muco-periosteum well beyond the growth, and a wedge-shaped or quadrilateral segment of bone is removed with the tumour by means of the chisel or saw.

**Resection of Upper Jaw.**—To facilitate the administration of the anæsthetic and to prevent blood entering the air

passages, it is usually advisable to perform a preliminary laryngotomy and pack the pharynx. Preliminary ligation, permanent or temporary, of the external carotid artery diminishes the hæmorrhage attending the operation, and through the incision made for the purpose the glands at the angle of the jaw and along the anterior border of the sterno-mastoid should be removed.

The *incision* which best conserves the branches of the facial nerve and gives free access to the bone is one carried through the middle line of the upper lip, round the ala, along the side of the nose to the inner angle of the eye, and along the lower border of the orbit on to the malar bone (Fig. 144). The vessels—angular, labial, infra-orbital and transverse facial—are secured with forceps, and after the reflection of the mucous membrane to the cheek has been divided the facial flap is folded outwards. The cartilage of the nose is then separated from the nasal process of the maxilla, the periosteum of the floor of the orbit freed, and a copper spatula placed between it and the bone to protect the eye from injury.

The limits of the superior maxilla having thus been defined, the next step in the operation is to separate the upper jaw from its connections. The junction of the nasal process of the maxilla with the nasal bone is first divided with the chisel or bone-pliers, the separation being effected at the highest part of the osseous anterior nares, and continued backwards through the lachrymal and ethmoid bones as far as the posterior part of the spheno-maxillary fissure.

The malar bone is then partly sawn across, and the division completed with bone-pliers or chisel. Before separating the affected half of the jaw from its fellow on the opposite side, an incision is made in the middle line through the mucous-periosteum of the hard palate, and the soft palate on the affected side is separated from the

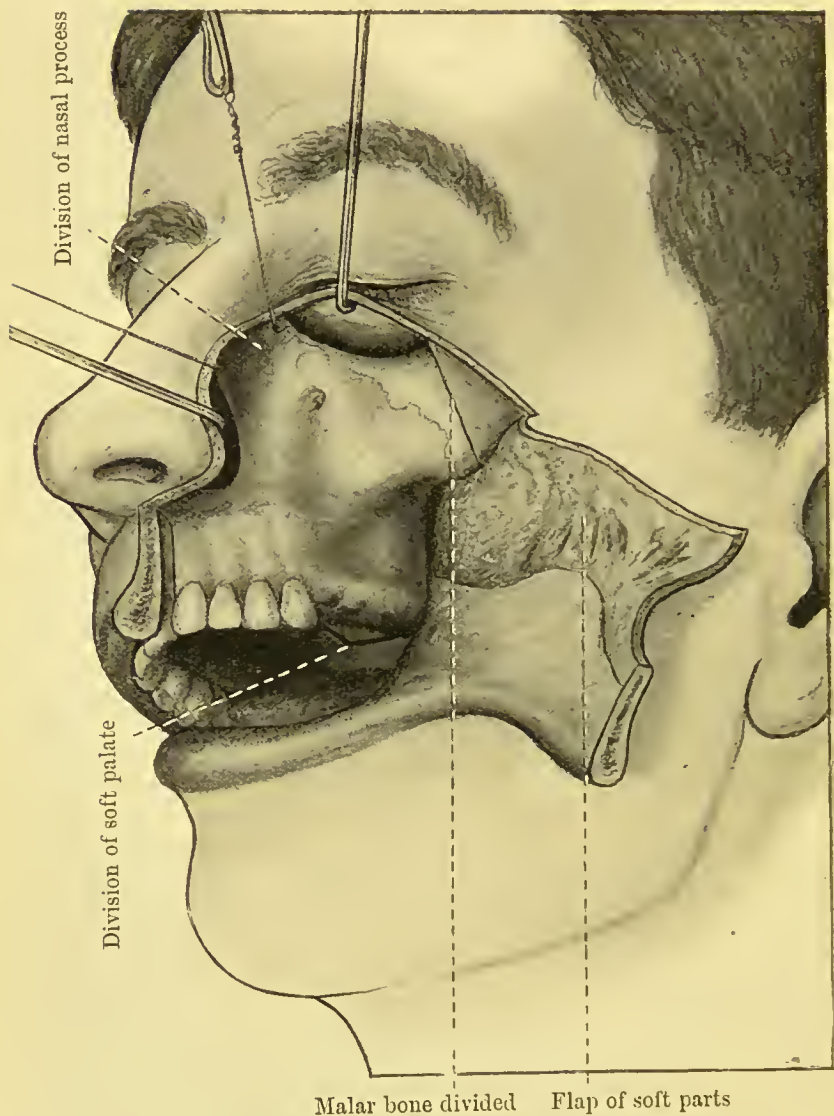


FIG. 144.—Resection of Maxilla.

hard with the thermo-cautery (Kocher). A narrow-bladed saw or a chisel is then applied to the alveolar process between the central incisor teeth, and after this portion of bone is divided the instrument is carried along the middle line of the hard palate. The facial flap



is now pulled well back and the posterior part of the mucous membrane, the buccinator and pterygoid muscles separated from the jaw, so as to expose the pterygoid process, which is chiselled through.

The segment of bone thus isolated is seized with lion forceps and forcibly wrenched out. A strong chisel pushed in behind the posterior wall of the maxillary sinus and used as a lever materially aids the separation.

After the bleeding has been arrested the cheek flap is replaced and sutured in position.

To diminish the risk of aspiration pneumonia, the patient is placed in the sitting posture as soon as he has recovered from the anæsthetic, and the mouth is frequently washed out with Condy's fluid and sprayed with hydrogen peroxide. The laryngotomy tube is removed the following day.

**Resection of the Lower Jaw.**—The operation varies with the portion of the jaw to be removed. In all cases care must be taken to avoid injuring the supra-mandibular branches of the facial nerve. When possible the integrity of the mandibular arch should be maintained by conserving the lower border of the bone, but when this is impracticable a simple wire splint or a piece of bone or ivory should be fixed in the gap to prevent the two fragments falling together.

*Removal of the Symphysis and Body.*—This can often be done through a mesial incision splitting the lip and soft parts down to the level of the hyoid bone. If this does not give sufficient room a lateral incision may be added, but this should be avoided if possible, as the division of the muscles and nerves interferes with swallowing and adds to the risk of aspiration pneumonia. The segment of bone to be removed having been defined, the soft parts are dissected off its anterior aspect and by means of a Gigli saw the division is effected, first on one side and then on the other. If the loose segment

of bone is then pulled upon, the diseased area in the mouth can be defined, and with scissors the mucous membrane is divided and the muscles separated from the inner aspect. The hæmorrhage is then arrested; sometimes it is necessary to plug the inferior dental canal to stop bleeding from the artery. The mucous membrane is sutured as far as possible, and to prevent the tongue falling back and interfering with respiration it should be transfixed with a silkworm gut suture and held forward. Means are taken to prevent the lateral segments of the jaw from falling together by interposing a temporary silver or ivory prop. After the wound has healed a denture is fitted, and the prominence of the chin and the alignment of the teeth are thus preserved.

*Removal of one Half of the Lower Jaw.*—The preliminaries are the same as for resection of the upper jaw. The incision should be planned so as to give access to the glands in the submaxillary triangle, which usually require to be removed at the same time. It passes through the middle line of the lower lip down to the hyoid bone, then upwards and backwards along the submaxillo-cervical fold to a finger's breadth behind and below the angle of the jaw, and curves upwards to the apex of the mastoid. If the red edge of the lip can be left intact, the cosmetic result is much better. The flap is dissected up, the facial vessels being secured before they are cut, and the lymph glands are removed. To enable the muscles attached to the jaw to be put upon the stretch, the bone is now divided a little to one side of the middle line by means of a Gigli saw, the central incisor on the affected side being first extracted if necessary. The reflection of the mucous membrane to the gum is next divided with scissors, and then the muscles—genio-hyoid, genio-hyoglossus, digastric, mylohyoid, and internal pterygoid—detached from the inner aspect of the bone.

If the jaw is now pulled well downwards the coronoid process can be brought into view, and its tip snipped off with bone-pliers, or the temporal muscle separated from it. The external pterygoid tendon attached to the condyle, and the capsule of the joint can be torn by twisting the bone. This avoids the risk of injuring the internal maxillary artery with cutting instruments, as it lies between the neck of the condyle and the internal lateral ligament.

The inferior dental artery is secured at the upper and posterior angle of the wound. The stumps of the muscles connecting the tongue to the lower jaw should be stitched forward before the flap is replaced and sutured. Special care is taken to stitch the red margin of the lower lip accurately.

*Removal of the Ramus alone.*—This operation is performed through an incision similar to the posterior part of that employed for removal of one half of the jaw.

The bone is exposed in front of the masseter muscle, and divided by means of a Gigli saw passed through the mucous membrane behind the last molar tooth. The subsequent steps are similar to those for removal of half the mandible.

The same precautions against aspiration pneumonia are taken as after excision of the maxilla, but as the mechanism of deglutition is more interfered with the risk is greater after removal of the mandible.

**Operation for Closure or Fixation of the Lower Jaw.**—When the cause of the fixation is in the joints, one or both condyles should be resected.

*Resection of the Condyle of Lower Jaw.*—A curved incision is made through the skin and fascia from a point just in front of the tragus, upwards and forwards over the zygoma, care being taken to avoid branches of the facial nerve and the superficial temporal vessels. Any outlying lobules of the parotid gland that may overlies the con-

dyle are hooked aside. A vertical incision is now made through the capsule of the joint, exposing the neck of the lower jaw. The condyle is then levered out of the joint, the external pterygoid tendon separated from the neck, which is divided with a Gigli saw or bone-pliers. It is important to remove a considerable portion of bone. It may also be necessary to remove the meniscus. When the meniscus has been removed, a portion of the temporal muscle or fascia, or of the masseter muscle, should be stitched in position between the socket and the stump of the neck of the bone, to prevent ankylosis.

A similar operation was performed by Annandale for *subluxation of the meniscus*. The cartilage may either be removed or stitched in position, after which the capsule is sutured and the wound closed.

When the fixation is due to cicatricial contraction of the soft parts, Esmarch's method of forming an artificial joint well in front of the cicatricial tissue is performed.

An incision is made under the lower border of the jaw, exposing the bone. The facial vessels are secured with forceps. A wedge-shaped segment of bone with its apex at the alveolus is then mapped out by dividing the periosteum in front and behind, and this portion of bone, the base of which measures about an inch and a quarter, is removed by means of a Gigli saw. To prevent osseous union taking place between the bony surfaces, portions of the masseter and internal pterygoid muscles are detached and interposed between the fragments. Active and passive movements must be carried out from the first.

## CHAPTER XXI

### OPERATIONS ON THE TONGUE AND SALIVARY GLANDS

EXCISION OF THE TONGUE FOR CANCER: *General; Whitehead's Operation; Syme's Operation; Excision of the Tongue with Resection of the Central Portion of the Mandible.* OPERATIONS FOR PAROTID TUMOURS: *Non-malignant; Malignant.*

#### EXCISION OF THE TONGUE FOR CANCER

THE operation for removal of the tongue varies with the site and extent of the growth and the degree to which adjacent parts, such as the floor of the mouth, the tonsil, or the jaw may be implicated. It is now generally recognised that freedom from recurrence of the disease can only be looked for if the whole of the lymphatic connections of the tongue are also removed. This involves a free dissection of the anterior triangle of the neck, and removal of the cervical fascia together with all the lymphatics. Most surgeons are content to remove the glands on the affected side only, but Kocher recommends that both sides be dealt with, as recurrence sometimes occurs in the glands on the side opposite to the primary growth. The glands may be removed at the same time as the tongue, but it is on the whole better to postpone the dissection till about ten days after the tongue has been excised, as recommended by Butlin. Kocher considers it preferable to clear out the glands first and remove the tongue after the wound has healed, usually in about eight days.



Professor F. M. Caird advocates the use of local anæsthesia (a  $\frac{1}{2}$  per cent. solution of cocain to which a few drops of adrenalin have been added) for the removal of the tongue. Even in extensive operations involving division of the jaw he has found that infiltration of the tissues to be divided ensures a painless operation.

To prevent saliva and blood from entering the air passages when under a general anæsthetic, the patient should be placed in the Trendelenburg position.

Some surgeons advocate the performance of a preliminary laryngotomy, on the ground that it facilitates the administration of the anæsthetic, and enables the back of the mouth to be packed so as to diminish the risk of blood passing into the air passages, but in our opinion this is only necessary when the disease is extensive and involves the floor of the mouth, the tonsil, or the jaw.

**Whitehead's Operation.**—This procedure, which consists in removing a carcinoma of the tongue through the mouth without an external incision, is most suitable in early cases in which the growth is limited to the anterior portion of one side of the tongue, and has formed no attachments to the floor of the mouth or to the jaw. The mouth is opened widely with a gag, and, to enable the tongue to be pulled well out of the mouth, each half is transfixed with a strand of silkworm gut passed through its substance behind the level of the frenum. The tongue is then split along the middle line to a point well beyond the level of the growth. The mucous membrane along the line of its reflection on to the alveolar process is next divided with scissors, and the vessels and nerves are thus exposed. The vessels entering the affected portion of the tongue may now be secured. The anterior pillar of the fauces is next divided, and the muscles between the tongue and the floor of the mouth are snipped through with scissors, any vessels that bleed being secured with forceps. Finally, the tongue is cut

across well behind the growth. The mucous membrane on the upper and under surfaces of the tongue is then sutured with chromic gut. The loop of silkworm gut in the healthy half of the tongue should be left in position, as it affords an easy means of preventing the tongue falling

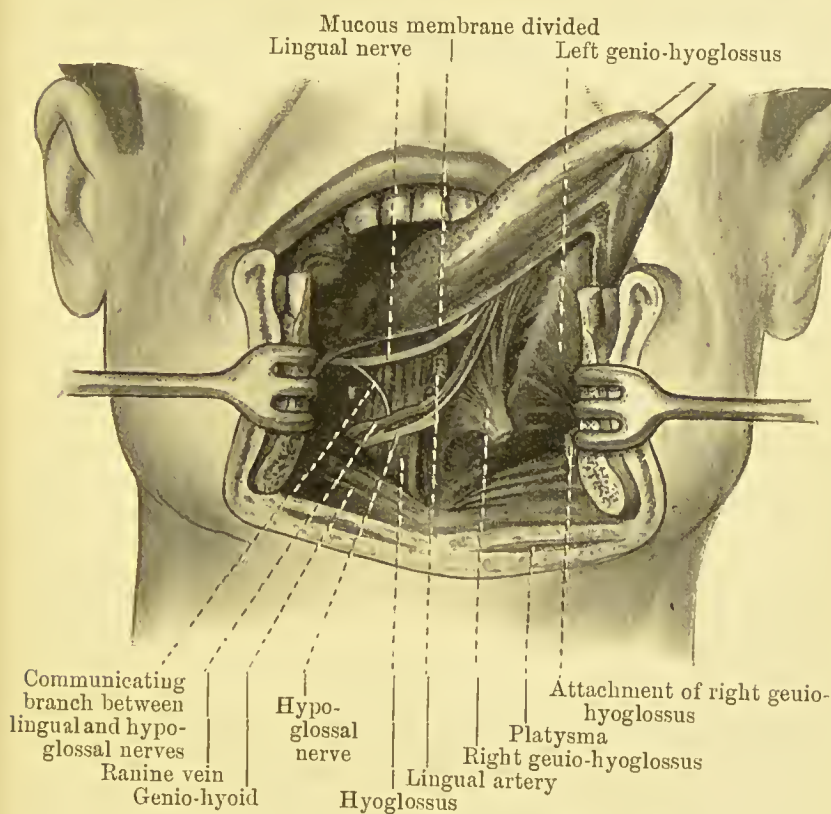


FIG. 145.—Excision of Tongue by Syme's Method.

back into the pharynx while the patient is recovering from the effects of the anæsthetic.

**Syme's Operation.**—When the disease is more extensive and involves the back of the tongue, and particularly when it has spread to the floor of the mouth, the fauces, or the soft palate, it is necessary to obtain freer access, by dividing the jaw in the middle line after the method of Syme (Fig. 145).

The tongue having been transfixed with a strand of silkworm gut, a mesial incision is carried through the lower lip over the chin and down to the hyoid bone, and the vessels secured with forceps. There are usually some lymph glands in the submental region, and these should be removed. Two holes are then drilled through the jaw on either side of the middle line to facilitate suturing of the bone after the tongue has been removed: the bone is more easily perforated at this stage than after it has been divided. A Gigli saw is now passed round the jaw in the space between the first and second incisor teeth on the affected side, and the bone divided. The two halves are then held apart with retractors and the tongue separated from the floor of the mouth by dividing the mucous membrane on each side. The mylo-hyoids and digastrics are separated in the middle line, and the genio-hyoids and genio-hyoglossi exposed. If the tongue is now drawn out towards the healthy side, the structures on its under surface are put upon the stretch, and the mucous membrane can be divided back to the anterior pillar of the fauces, which is then cut across. The ranine vein, the hypoglossal nerve, and the lingual nerve are seen on the outer surface of the hyoglossus, and the lingual artery is found passing forward and upward between the hyoglossus and the genio-hyoglossus, where it can be ligated. The muscles inserted into the genioid tubercles are separated from the bone, and any diseased tissue dissected up from the floor of the mouth. The tongue can now be more freely withdrawn from the mouth, and the mucous membrane is divided well behind the growth. The tongue is then cut through and the bleeding vessels secured. Kocher lays stress on the advantage of employing the thermo-cautery for the division of the extrinsic muscles, the mucous membrane, and the substance of the tongue.

The two halves of the jaw are sutured with silver

wire, and the soft parts stitched accurately in position. A little above the hyoid bone at the posterior part of the incision an opening is left, into which a strip of iodoform gauze is inserted (Kocher). Before the patient is returned to bed a strand of silkworm gut is passed through the stump of the tongue to prevent it falling back and obstructing the respiration.

**Excision of the Tongue with Resection of the Central Portion of the Mandible.**—When the disease infiltrates the floor of the mouth and the jaw in the region of the symphysis, it is necessary to remove a portion of the bone along with the growth.

A mesial incision is made through the lip down to the hyoid bone, and the soft parts are cleared from the bone on each side until a healthy part is reached.

The mandible is divided with a Gigli saw, and the central segment is removed together with the growth in the tongue and the floor of the mouth. Caird recommends that the thick lower border of the bone should be conserved to maintain the integrity of the mandibular arch, and he has never seen recurrence take place in the portion of bone so preserved. When this is not done the portion of bone removed should be replaced by a mechanical prop, such as a piece of ivory, to prevent the lateral segments falling together.

## OPERATIONS FOR PAROTID TUMOURS

**Excision of Non-malignant Tumours.**—The commonest tumour met with in the parotid gland is the so-called "mixed" tumour, which, in its early stages at least, is encapsulated and can be shelled out of the compressed and atrophied salivary tissue surrounding it.

The incision is made over the most salient part of the swelling, and runs parallel with the main branches of the facial nerve. It should be long enough to admit



of free exposure of the growth. After the integument has been divided, the boundary between the tumour and the parotid tissue must be clearly defined, and in doing so every care must be taken to avoid injuring the branches of the facial nerve. These can be recognised by the contraction of the facial muscles which takes place when they are stimulated.

If the growth is soft and vascular, as much as possible of the capsule should be removed after the tumour has been shelled out.

**Excision of the Parotid for Malignant Tumours.**—A malignant tumour calls for removal of the entire parotid gland and of any of the adjacent structures to which the growth has spread. The facial nerve must usually be sacrificed.

The incision employed will depend on the size and disposition of the growth, but it must be so planned as to give free access to all the outlying parts of the gland, and to enable the hæmorrhage to be controlled.

These indications are usually met by a  $\neg$ -shaped incision, the vertical limb of which begins at the apex of the mastoid and passes along the anterior edge of the sterno-mastoid as far as the level of the upper border of the thyroid cartilage, the horizontal limb being carried over the most salient part of the swelling. The two flaps thus delimited are reflected and held apart. Any portion of skin infiltrated by the tumour should be removed. Kocher recommends an incision beginning on the temple two fingers' breadth above the zygoma and running vertically downwards in front of the tragus as far as a point on the anterior border of the sterno-mastoid two fingers' breadth below the angle of the jaw.

The tumour is exposed by incising the deep cervical fascia, and its lower and anterior borders are defined and separated, the transverse facial artery and the parotid duct being divided. On reaching the posterior part, the



external jugular vein is exposed and must be divided between ligatures. The edge of the sterno-mastoid is then defined, and if it is invaded by the tumour a portion of the muscle must be removed. The fingers are now passed under the mass to raise it from the posterior belly of the digastric and to expose the external carotid artery, which must be secured and divided between ligatures. The temporal fascia is divided above the tumour, and the superficial temporal vessels secured before being cut.

In separating the deep connections, the growth may be found attached to the capsule of the joint, a portion of which must be removed. Just behind the joint the external carotid divides into the superficial temporal and internal maxillary arteries, which must be secured. If the tumour is adherent to the cartilage of the external auditory meatus or to the mastoid process, portions of these must be removed with it.

## CHAPTER XXII

### OPERATIONS ON THE NECK

FOR PERMANENT WRY-NECK. FOR SPASMODIC WRY-NECK. FOR RETRO-PHARYNGEAL ABSCESS. BUTLIN'S OPERATION FOR MALIGNANT GLANDS. OPERATION FOR TUBERCULOUS GLANDS. FOR REMOVAL OF THYMUS GLAND.

**Operation for Permanent Wry-Neck.** — Subcutaneous tenotomy of the sternal and clavicular attachments of the sterno-mastoid—at one time the favourite method of treatment—has been entirely replaced by the *open operation*, which admits of all the structures at fault, including the cervical fascia, being thoroughly divided without any risk of injuring other structures in the neck. A horizontal incision is made a finger's breadth above the clavicle, and each of the heads of origin of the sterno-mastoid thoroughly and completely divided. Any shortened bands of fascia that stand out after division of the muscle are also freely divided. It may then be necessary to divide the scalenus anticus, care being taken to avoid injuring the phrenic nerve. The wound is sutured, and the head fixed in a slightly over-corrected position by means of an elastic bandage carried under the axillæ and round the body.

**Operation for Spasmodic Wry-Neck.** — *For rotatory spasm* Kocher recommends division of the affected muscles in preference to neurotomy of the upper four cervical nerves. In a case, for example, of right-sided rotatory spasm the *left* sterno-mastoid is first divided, an incision being made through the skin and fascia,

exposing the upper third of its anterior border, and the muscle cut across a little below its attachment to the mastoid process.

The posterior muscles on the *right* side of the neck—the splenius capitis and colli, the trachelo-mastoid, and the obliquus capitis inferior—are then divided. A transverse incision is made, two fingers' breadth below the superior curved line of the occiput, downwards and outwards from the anterior border of the trapezius to the sterno-mastoid. The splenius capitis is then divided, care being taken to avoid the small occipital nerve and the occipital artery. The trachelo-mastoid is next divided below its insertion into the mastoid, and then the slips of the splenius colli at their attachments to the transverse processes of the first and second cervical vertebræ. The complexus is drawn inwards to expose the obliquus capitis inferior, which passes from the spine of the second cervical vertebra to the transverse process of the atlas. In dividing this muscle the great occipital nerve, which hooks round its lower border, is to be avoided.

When there is *extensor spasm* the attachments to the skull of the trapezius and complexus, the rectus capitis posticus major and minor, and the obliquus superior must also be divided.

**Operation for Retro-pharyngeal Abscess.**—A tuberculous abscess in the retro-pharyngeal space should always be opened from the outside by an incision made along the posterior border of the sterno-mastoid, as was first suggested by John Chiene. After the skin and fascia have been divided, and the superficial cervical nerves and the external jugular vein identified and held aside, the sterno-mastoid is drawn forward. The omohyoid is defined and cut across, and the internal jugular vein, which now comes into view, drawn forward with a broad retractor. The scaleni are thus exposed, and the

abscess can be seen or felt in front of the vertebræ. A blunt instrument is now pushed through the deep fascia into the cavity, and the pus and tuberculous debris removed. The abscess cavity is then filled with iodoform emulsion, and the external wound closed without drainage.

**Butlin's Operation for removal of Malignant Glands in the Neck** (Fig. 146).—The structures on the side of the neck to be operated upon are put on the stretch by raising the shoulders on a sand-bag and drawing the head backwards and to the opposite side. An incision is made along the anterior border of the sterno-mastoid, from the tip of the mastoid process to the sterno-clavicular joint, and from a point opposite the level of the upper border of the thyroid cartilage a second incision is carried upwards and forwards to the symphysis menti. These incisions go through the skin and platysma, the external jugular vein and the great auricular nerve being saved if possible, and the integumentary flaps thus delimited are reflected until the whole of the cervical fascia covering the anterior triangle is exposed. The anterior edge of the sterno-mastoid having been defined from below upwards, the muscle is drawn back with a broad retractor and the dissection continued until the carotid sheath is exposed. The cellular tissue, which contains the cervical lymphatics, is then dissected from below upwards in one piece, exposing the great vessels in their entire length. The depressor muscles of the hyoid are cleared, and all processes of fascia and fat passing between them and around the vessels are removed. The descendens hypoglossi nerve should be avoided. The connective tissue in the submaxillary triangle is dissected off the digastric muscle, and the submaxillary salivary gland as well as the lymph glands is removed. A gland is usually found between the angle of the jaw and the anterior border of the internal pterygoid muscle



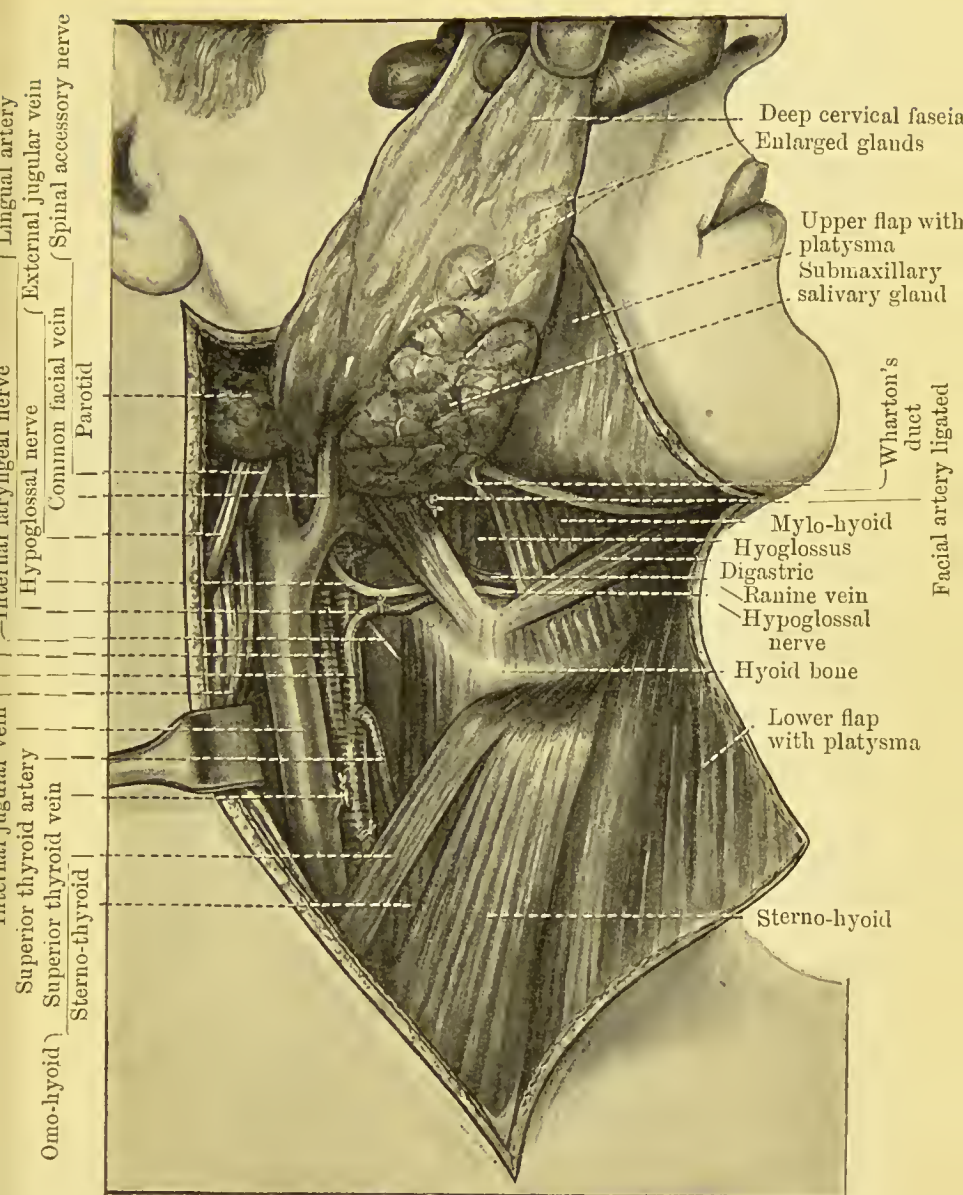


FIG. 146.—Butlin's Operation for Removal of Malignant Glands in Neck.

The dissection is carried forward to the submental region, and the space between the genio-hyoid muscles, which usually contains a lymph gland, is cleared out, and



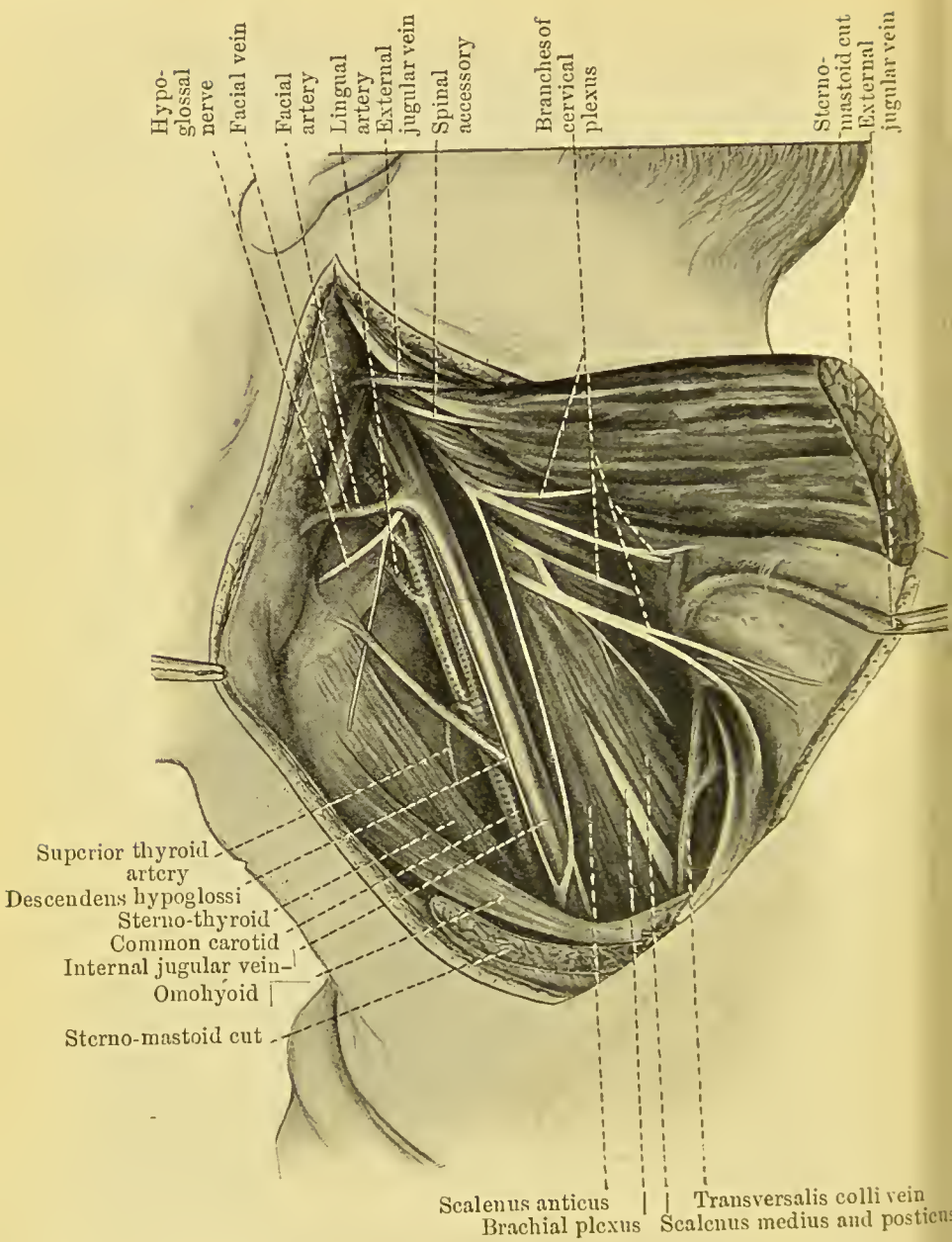


FIG. 147.—Deep dissection of neck after division of Sternomastoid.

the supra-hyoid glands between the anterior bellies of the digastric muscles removed. In the upper and

posterior angle of the wound special care must be taken to avoid injuring the spinal accessory nerve, which runs obliquely downwards and backwards to enter the sternomastoid. To ensure removal of all the parotid (upper carotid) group of lymph glands it is usually necessary to remove the lower part of the parotid salivary gland (Butlin). Sometimes the glands are so firmly adherent to the internal jugular vein that it is necessary to remove a segment of this vessel, the vein being first secured by passing ligatures round it with an aneurysm needle. It may even be necessary to excise a portion of the external carotid artery above the origin of its superior thyroid branch.

After all hæmorrhage has been arrested, the cut surface of the parotid gland should be sutured with catgut before the skin flaps are replaced and stitched in position. A long narrow glass drainage tube is inserted at the lower angle of the wound and left in position for forty-eight hours. A considerable quantity of saliva sometimes escapes from the cut surface of the parotid, but a permanent salivary fistula never results.

If the glands on the opposite side of the neck are implicated, a similar operation should be carried out after an interval of a week or ten days.

**Operation for Tuberculous Glands of the Neck.**—When the glands are limited to the anterior triangle, an operation similar to Butlin's may be performed, the incision being made in the line of the folds of the neck.

When both anterior and posterior triangles are implicated, the best access is obtained by a Z-shaped incision, the upper limb running below and parallel with the mandible, the vertical limb along the sternomastoid, and the lower limb above and parallel with the clavicle.

In exposing the glands, the common facial and other venous trunks may require to be clamped and tied.

Care must be taken not to injure the important nerves, particularly the spinal accessory, the vagus, and the phrenic. The infra-maxillary branches of the facial, the hypoglossal and its descending branches, and the motor branches of the deep cervical plexus are liable to be injured, and should if possible be conserved. The dissection is rendered easier, and is attended with less risk of injury to the nerves if, instead of a knife, the conical scissors of Mayo are employed as a tissue separator. In the removal of matted glands beneath the sterno-mastoid it may be necessary to cut this muscle across and to reflect the divided ends upwards and downwards (Fig. 147); if the muscle itself is infiltrated with tubercle, the affected portion is removed along with the glands. When the glandular mass is closely adherent to the internal jugular vein, the operation is rendered easier by ligating the vein at the root of the neck and removing it from below upwards along with the glands (Watson-Cheyne). When the glands are extensively affected on both sides of the neck it may be advisable to allow an interval to elapse rather than to operate on both sides at one sitting. In closing the wound, the platysma and cervical fascia should be re-united by means of a fine catgut suture, and the skin edges brought together by Michel's clips; if drainage is called for, a very fine glass tube should be introduced through the skin and fascia at a little distance from the main wound.

**Removal of the Thymus Gland.**—If it is causing pressure on the trachea, the thymus gland can be exposed by a longitudinal incision made in the middle line or by Kocher's low "collar" incision (p. 352). After the skin and fascia have been divided the capsule of the gland is seen. By making traction on it the gland can be pulled up from behind the sternum. The upper part of the gland lies against the trachea, and the lower part on the great vessels or pericardium behind the sternum.

The great vessels and the phrenic nerve run close to the gland on each side, and on the left side there are also the vagus and recurrent laryngeal nerves. As all these structures are closely connected with the capsule, the gland must be shelled out, the empty capsule being held up with stitches. The operation is not attended with much bleeding.

## CHAPTER XXIII

### OPERATIONS FOR GOITRE

EXCISION OF GOITRE: *Koehler's Operation for Movable Goitre; Operation for Large Adherent Goitre; Excision of a Median Goitre; Operation for Intra-thoracic Goitre.*

#### **Koehler's Operation for Excision of a Movable Goitre.—**

A transverse curved incision—the *collar incision of Koehler* (Fig. 148)—affords free access and leaves an almost imperceptible scar. It is carried from the outer border of one sterno-mastoid to the outer border of the other, and curves slightly downwards over the most prominent part of the goitre, the centre of the incision usually falling just below the cricoid cartilage. After the skin and platysma are divided and the cervical fascia exposed, the two anterior jugular veins and the “oblique veins” of Koehler, which run along the anterior border of the sterno-mastoid, are seen, and must be secured between two ligatures or with forceps. The external jugular veins can usually be avoided.

The sterno-hyoid, sterno-thyroid, and omo-hyoid muscles, which are spread out over the goitre, are now clearly defined and separated in the middle line, and the subjacent layer of the cervical fascia is divided upwards and downwards on the finger passed beneath it. The muscles are then retracted sufficiently to expose the tumour, or if this is not possible they must be divided, in which case they should be cut near their attachments to the hyoid bone in order to preserve their nerve supply and give better access to the superior



thyroid artery, and to secure that when they are stitched the line of suture will lie at a different level from that of the skin incision (C. H. Mayo).

In exposing the portion to be removed, the external capsule is carefully divided until the actual substance



FIG. 148.—Kocher's Collar Incision for Goitre (*a*) ; and Incision for Laryngotomy (*b*).

of the goitre is reached. A finger is now passed underneath the divided muscles and capsule, and the goitre is "disloated," all fibrous bands passing from the neighbouring tissues to the gland being secured with forceps before being cut, as they contain the "accessory veins."

The main vessels are now ligated. With a blunt dissector the capsule is separated from the upper corner

of the thyroid until the superior thyroid artery and vein are isolated and secured between two ligatures.

The inferior thyroid vessels are next exposed by retracting the muscles on the affected side and pulling the goitre well over to the opposite side. Special caution is necessary in securing these vessels, on account of their close connection with the recurrent laryngeal nerve which usually runs up behind them. The thyroidea ima vessels, when present, are secured as they enter the lower pole of the goitre.

The isthmus is next defined and separated from the trachea, and the "communicating veins," which run along its upper and lower borders, secured. Strong crushing forceps are then applied in the middle line, and the band of compressed tissue left when the forceps are removed is tied with a strong ligature before being cut across.

Finally, the attachments of the affected half of the thyroid to the trachea and cricoid cartilage are separated, special care being taken not to injure the recurrent laryngeal nerve as it passes beneath the lower border of the larynx. To ensure the safety of the nerve, and to avoid enucleating the parathyroid glands, which lie in the fascia in relation to this part of the thyroid, a thin slice of the gland may be left adherent to the trachea.

The hæmorrhage is then arrested, any muscles that have been divided are sutured, and the skin wound is closed, provision being made for drainage by introducing a small glass tube through a mesial puncture made for the purpose.

The same operation is performed for *exophthalmic goitre*, but it is attended with more anxiety owing to the existing thyroidism.

**Operation for Large Adherent Goitres.**—*Difficult Cases.*  
—When the growth is of large dimensions, or when it has become adherent as a result of inflammation, or is malig-

nant, the collar incision does not give satisfactory access, and the *angled incision* may be preferred (Fig. 149). It begins over the sterno-mastoid muscle of the side most affected at the level of the thyroid cartilage, passes forwards to the middle line in the natural fold of the skin,

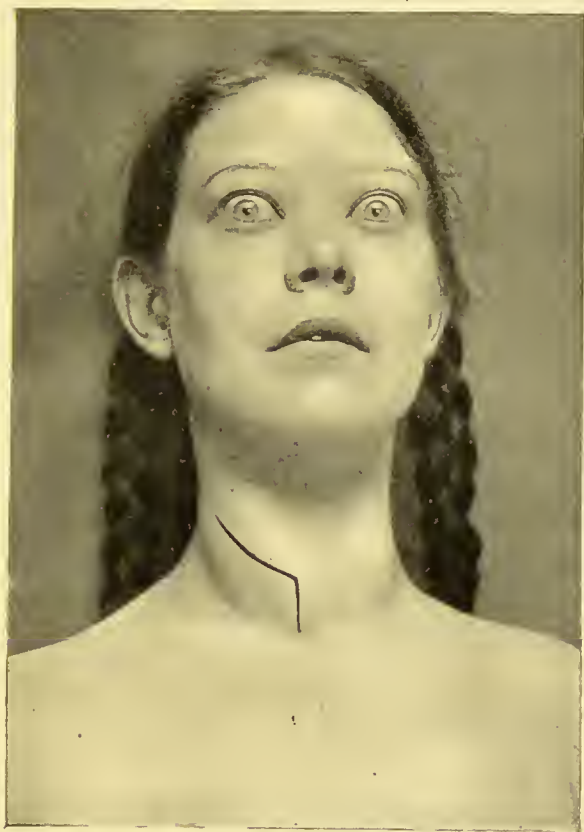


FIG. 149.—Kocher's Angled Incision for Goitre.

and then vertically downwards to the supra-sternal notch. The sterno-mastoid is freed and retracted, the depressor muscles divided near to their upper attachments and turned downwards. The subsequent steps of the operation are similar to those above described.

**Excision of a Median Goitre.**—For tumours implicating the isthmus the collar incision is suitable. The

removal of the isthmus involves division of each lateral lobe, and the crushing forceps should if possible be applied where there is a natural constriction of the gland.

**Operations for Intra-thoracic Goitre.**—The collar incision is made low down in the neck, and the gland exposed as in the other forms of goitre. The tumour is then examined to determine with which lobe of the thyroid the retro-sternal portion is connected. The vessels at the upper pole of the affected lobe are secured, the isthmus crushed and divided, and, after all accessible vessels have been secured, the intra-thoracic prolongation is seized with Kocher's goitre forceps and forcibly dragged upwards. It is sometimes necessary to pass a spoon-shaped elevator underneath the growth to lever it up. If the intra-thoracic portion is cystic, its removal is facilitated by incising the cyst and dragging upon the collapsed cyst wall. It may even be necessary to break up the growth and remove it piecemeal. The inferior thyroid artery is then secured, and the operation completed as in other forms of goitre.

**Operation for Malignant Goitre.**—The angled incision is to be preferred, and the skin must be freely divided. The vessels should be secured as far from the gland as possible in order that all the structures to which the growth is adherent may be removed along with the thyroid. Infected lymph glands must also be removed.

## CHAPTER XXIV

### OPERATIONS ON THE AIR PASSAGES

THYROTOMY. LARYNGOTOMY. TRACHEOTOMY: *High; Low*  
EXCISION OF THE LARYNX.

**Thyrotomy.**—This operation consists in splitting the thyroid cartilage in the middle line for the removal of papillomata or foreign bodies, or for purposes of exploration in cases of cancer.

A preliminary tracheotomy is first performed (Fig. 150), and then, with the patient's head extended, a mesial incision is carried from the hyoid bone down to the cricoid cartilage, dividing the skin and fascia. The vessels are secured with forceps and ligated. The depressor muscles are held aside, and the projecting angle of the thyroid cartilage cleared. The thyroid cartilage is then split accurately in the middle line between the anterior ends of the vocal cords. If this is done from below upwards, and the edges of the cartilage are held aside with hooks, injury to the vocal cords can be avoided and a satisfactory view of the interior of the larynx obtained.

A papillomatous growth is snipped away with scissors, and the edges of the cartilage are accurately stitched in position with chromic catgut sutures which do not penetrate the whole thickness of the cartilage, care being taken that the vocal cords are exactly opposite one another.

If a cancerous tumour is found, the affected portion



of the larynx must be removed—*Partial laryngectomy*. The mucous membrane well beyond the limits of the

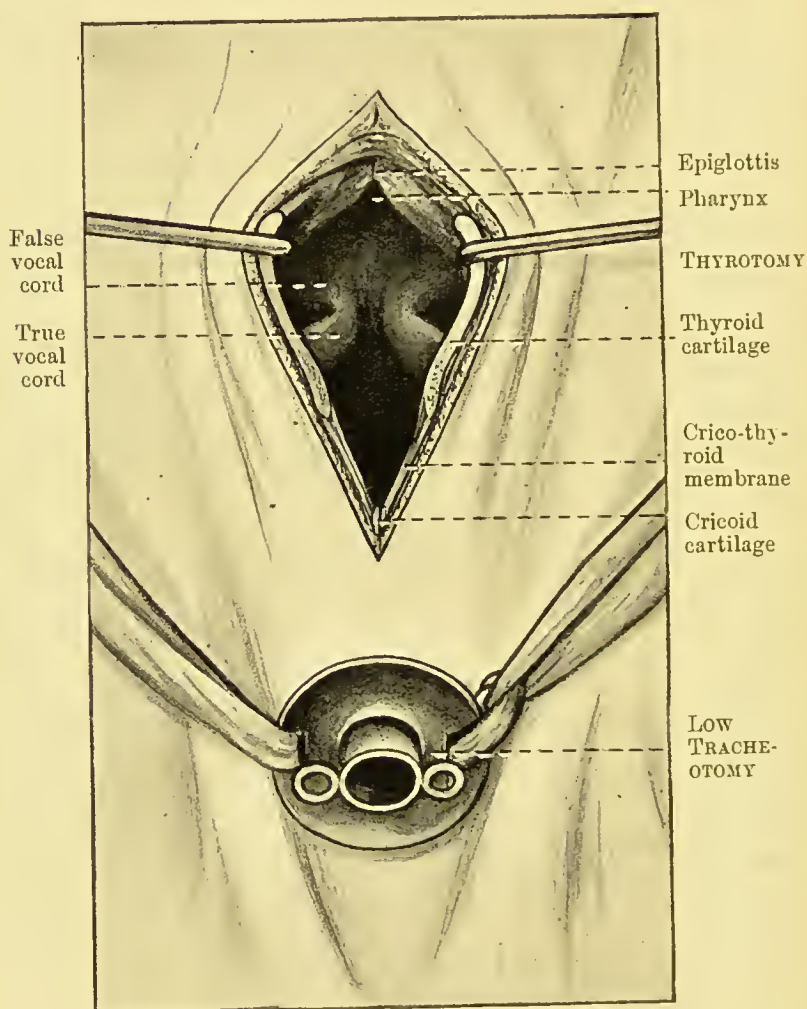


FIG. 150.—Thyrotomy and Low Tracheotomy.

growth is divided with the thermo-cautery or with a knife, and if the tumour infiltrates the cartilage this is cut with strong scissors, the muscles attached to its outer surface having first been separated if they are not involved in the growth. Iodoform powder is rubbed on

the raw surface and the cavity packed with iodoform gauze, which is removed in a few days.

**Laryngotomy** (Fig. 148).—This operation, which consists in opening the larynx by dividing the crico-thyroid membrane, is performed in emergencies when a person is threatened with suffocation, and as a preliminary in extensive operations on the jaws, pharynx, or tongue.

A mesial incision is made from the upper border of the thyroid cartilage to the lower border of the cricoid, the deep fascia divided in the middle line, and the sterno-thyroid muscles pushed aside. We have found that a horizontal incision made over the crico-thyroid membrane, although it is attended with more bleeding from the superficial veins, is less liable to become infected, and yields a better cosmetic result. The thyroid and cricoid cartilages are then defined, and the crico-thyroid membrane incised transversely, the knife being inserted close to the upper edge of the cricoid cartilage to avoid injuring the crico-thyroid arteries. The incision must not be extended far enough laterally to injure the crico-thyroid muscle. The tube, which should be oval in its transverse section, is then inserted. In children the crico-thyroid space may not afford sufficient room, and it may be necessary to divide the cricoid cartilage.

**Tracheotomy**.—The trachea may be opened either above or below the thyroid isthmus, which usually covers the second, third, and fourth tracheal rings.

In adults the operation may be performed under local anaesthesia, but in children it is usually advisable to administer a general anaesthetic. This, however, must be done with great care, as the dyspnoea may suddenly become extreme and necessitate the operation being completed rapidly and artificial respiration employed.

**High Tracheotomy**.—The operation above the isthmus is to be preferred, except in special conditions, as it is more easily and rapidly performed, and is attended

with less hæmorrhage and with fewer risks of septic complications in the connective-tissue planes of the neck. When the isthmus is well developed, the space above it is so small that it is usually necessary to divide the cricoid cartilage—*Cricotracheotomy*.

A roller pillow is placed beneath the neck to put the parts on the stretch, and an incision is made from the middle of the thyroid cartilage downwards for about two inches, or, as we prefer, a horizontal incision. After the skin and fascia are divided and the superficial veins secured, the adjacent edges of the sternohyoid muscles are separated and drawn aside; the cross branch between the anterior jugular veins and any other veins met with are secured with forceps before being divided. The trachea is then exposed by dividing transversely the pre-tracheal layer of the deep fascia, which passes from the cricoid to the isthmus of the thyroid. The isthmus is next separated from the trachea by blunt dissection and pulled well down with a retractor. If it cannot be displaced sufficiently, a double ligature should be passed round it with the aid of an aneurysm needle and each side secured, after which it is divided in the middle line.

All active bleeding having been arrested, the larynx is steadied by inserting a sharp hook in the lower border of the cricoid cartilage, and the trachea is opened by thrusting a short broad-bladed knife through the exposed rings. The back of the knife should be directed downwards, and the opening in the trachea enlarged upwards sufficiently to admit the tracheotomy tube. The slit in the trachea is then opened up with a trachea-dilator or by inserting a small sharp hook into the cartilage on each edge, and the outer tube introduced and fixed with tapes. The skin wound beyond the tube may be brought together with horsehair stitches. The inner tube is not fixed, so that it may be coughed out if it

becomes blocked, and that it may be frequently removed and cleaned by the nurse. The tube should be discarded as soon as the patient is able to breathe by the natural channel.

**Low Tracheotomy.**—When tracheotomy is performed as a preliminary to pharyngotomy, laryngotomy, or laryngectomy, the operation below the isthmus is to be preferred, and it is best done some days before the more important operation. The low operation is also called for in the removal of foreign bodies which have become impacted low down in the trachea or in one of the bronchi.

The incision is made between the cricoid cartilage and the episternal notch, and the dissection is carried out on the same lines as in the high operation (Fig. 150). In addition to various cross branches of veins, the inferior thyroid veins will be found in front of the trachea, and in exceptional cases the thyroidea ima artery. In the child, the innominate artery may project above the episternal notch, and the remains of the thymus gland may be found in front of the trachea.

The low operation is more difficult than the high one, as there are more veins to be secured, and since the trachea lies farther from the surface, a longer tube must be used.

In elderly persons the rings of the trachea may be calcified or ossified and refuse to yield to the knife. The air passage should then be incised between two rings of the trachea, and one blade of a strong pair of scissors inserted into the passage to divide the rings.

**Complete Laryngectomy.**—**Excision of the Larynx** (Heron-Watson, 1868).—A preliminary low tracheotomy may be performed several days before the excision is undertaken, but we do not consider this advisable. To prevent the entrance of blood into the lungs, the patient is placed in the Trendelenburg position.



A vertical incision is then made from the hyoid bone nearly to the episternal notch, and from its upper end horizontal incisions are carried out on each side as far as the sterno-mastoid muscles to admit of the soft parts covering the larynx being reflected. Kocher recommends the "collar incision," placed lower than for goitre.

The isthmus of the thyroid is secured by a double ligature and divided, the trachea cut across at its junction with the cricoid, and its upper end stitched to the skin at the lower end of the wound. A sharp hook is fixed in the cricoid cartilage, the larynx pulled to one side, and the mucous membrane of the pharynx separated posteriorly. The attachment of the inferior constrictor of the pharynx to the larynx is divided, and the cavity of the pharynx entered. The larynx is now pulled to the opposite side and a similar dissection carried out. The thyro-hyoid membrane and the superior cornua of the thyroid cartilage are next cut across, completing the excision. The space from which the larynx has been removed is then packed with gauze and treated by the open method.

The patient is fed for a few days through a tube passed into the œsophagus, and by nutrient enemata.



## CHAPTER XXV

### OPERATIONS ON THE BREAST

#### EXCISION OF SIMPLE TUMOURS. OPERATIONS FOR CANCER OF THE BREAST

**Excision of Simple Tumours.**—If situated *near the surface*, a simple circumscribed tumour in the breast can be excised through a linear incision placed directly over it and radiating from the nipple, the skin, subcutaneous fat, and a thin layer of gland tissue being divided and the tumour shelled out.

If the tumour is *in the deeper part of the gland* the plastic operation suggested by Gaillard Thomas is to be preferred. A curved incision is made in the thoraco-mammary fold, towards the outer and lower border of the breast, exposing the lower edge of the pectoralis major muscle. The breast is then separated from the pectoral fascia and reflected upwards and inwards until its deep aspect is freely exposed. The tumour can then be located and removed, either by shelling it out of its capsule or by resecting a wedge-shaped segment of mammary tissue including the growth. After the hæmorrhage has been arrested, the gap in the breast should be closed by buried sutures, the gland folded back into place, and the skin incision closed, a small glass drainage tube being inserted and retained for forty-eight hours.

When *the whole gland* is implicated in the disease—for example, in cases of multiple cystic adenomata—the entire breast can be excised by Thomas's method. The

gland is separated from the pectoralis major behind and from the skin in front. The disfigurement is comparatively slight, as the nipple is retained and the scar falls in the sub-mammary fold.

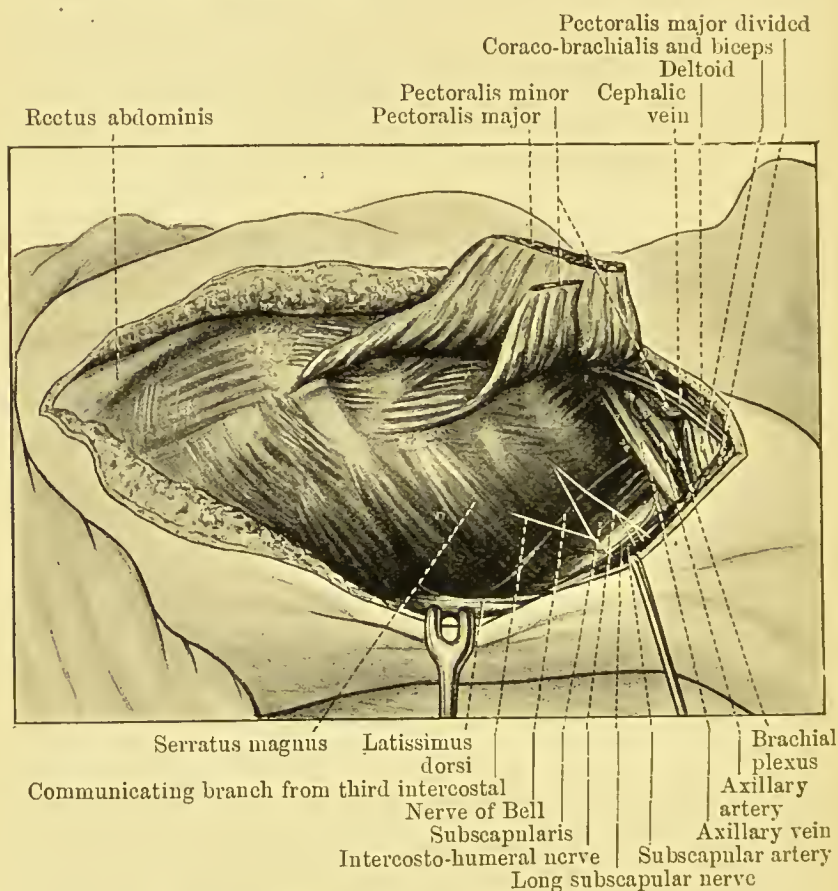


FIG. 151.—Parts exposed in the Complete Operation for excision of the Breast.

If it is desirable to remove the nipple and a portion of the skin over the breast, an elliptical incision is employed.

**Operation for Cancer of the Breast.**—The only treatment is complete removal of the breast and of all the adjacent tissues to which the disease is liable to have

spread. The limits of the operation have been gradually extended, and in order to prevent local recurrence it is now considered necessary to remove: (1) the tumour, together with the whole of the mammary gland, the skin over it, and the circum-mammary fat in which it lies; (2) the pectoral fascia and the extension of the deep fascia over the upper part of the rectus abdominis and external oblique muscles; (3) the pectoral muscles in whole or in part; (4) the fat, lymph vessels, and glands in the axilla, and those in relation to the pectoralis minor, costo-coracoid membrane, and sub-scapular vessels; (5) if the supra-clavicular glands are enlarged they also should be removed.

There are many different ways of performing the operation so as to fulfil these requirements.

The following description, based on the method employed by Kocher, may be taken as illustrative of the lines on which the modern operation is carried out (Fig. 151).

*Dissection of Axilla.*—The arm being fully abducted, an incision is commenced at a point on the clavicle slightly internal to the groove between the deltoid and pectoralis major, and is carried through skin and fascia over the pectoral muscle and across the axilla to its posterior fold.

The cephalic vein, which is exposed in the furrow between the deltoid and pectoral muscles, should if possible be avoided, as it will form an important channel for the return of blood from the limb in the event of the axillary vein being interfered with.

The axillary fascia is cleared from the lower border of the pectoralis major, a finger is passed underneath the muscle about an inch from its insertion into the humerus, and the muscle is cut across. It is usually necessary to apply forceps to one or two bleeding-points in the muscle. The axillary vessels, notably the large blue

vein, surrounded by fat and connective tissue, then come into view, and if it is desired to expose them as far up as the clavicle, it is necessary to divide the pectoralis minor close to its insertion into the coracoid process.

The muscles forming the posterior boundary of the axilla—latissimus dorsi and teres major—are defined by separating the axillary fascia from them.

The finger is then passed into the apex of the axilla, and by gauze dissection the fat, lymphatics, and fascia are separated from above downwards until the whole length of the axillary vein is cleared.

Any branches of the axillary vessels that require to be divided should be seized with two pairs of forceps a short distance from the main trunks and cut between the forceps.

When the axillary contents have been cleared out in this way, the subscapular nerves are exposed in the furrow between the latissimus dorsi and the subscapularis, and the long thoracic nerve (of Bell) is seen on the surface of the serratus magnus.

The separation of the fascia covering the subscapularis, latissimus dorsi, and serratus magnus is continued down to the lower limit of the wound.

*Removal of the Breast.*—In planning the incision for delimiting the breast, consideration must be had to the situation of the main tumour, so that a wide area of the skin overlying and surrounding it may be removed. If the growth lies *under the areola*, the delimiting incision takes the form of a wide ellipse, the sides of which extend well beyond the limits of the tumour.

When the tumour is situated *towards the periphery* of the breast the incisions must be modified accordingly, the ellipse being made wider on the affected aspect, or a V-shaped incision being carried beyond the growth.

From the axillary wound, an incision is carried above



the breast and the skin dissected from the subcutaneous fat as far up as the lower border of the clavicle and inwards to the middle of the sternum. The bleeding-points are secured with forceps, and the flap covered with a large gauze swab wrung out of hot saline solution.

The breast is now pulled towards the middle line by the assistant, and an incision is made below the breast and the skin reflected beyond the edge of the latissimus dorsi. At its lower end, this flap should be dissected down in the epigastric triangle far enough to expose the fascia covering the upper digitations of the external oblique muscle and the anterior sheath of the rectus abdominis.

The breast is now pulled towards the axilla and the fibres of origin of the pectoralis major and minor separated in turn, the perforating branches of the internal mammary artery being secured with forceps before they are divided. At the lower angle of the wound the fascia covering the upper part of the sheath of the rectus abdominis and the exposed portion of the external oblique are dissected off.

The dissection of the breast from the chest wall is continued until the posterior axillary border is reached. The fascia is then cleared from the portions of the subscapularis, latissimus dorsi, and serratus magnus that could not be reached from the axillary wound, and the breast and axillary contents are removed in one piece.

*Closure of the Wound.*—Any blood vessels divided close to the main trunks in the axilla, and the perforating branches of the internal mammary, should be secured with ligatures; bleeding from other vessels can usually be arrested by torsion.

A large-sized drainage tube is introduced through a puncture opening made for the purpose in the posterior flap, just in front of the latissimus dorsi.

The flaps are then adapted to one another and brought



into apposition as accurately as possible and sutured with horsehair or silkworm gut. When the wound cannot be completely closed, the flaps may be mobilised by "under cutting," or the raw surface may be covered with Thiersch grafts. Skin which is unlikely to retain its vitality because of tension should be scored with the knife (C. H. Mayo).

When the wound cannot be completely closed by the flaps, a few Thiersch grafts should be taken from the thigh and placed on the raw surface left.

The dressing is then applied, a large pad of wool being placed over the back, as the blood and serum escaping from the drainage tube tend to reach this part. The upper arm is abducted to the level of the shoulder, and the axilla is well banked up with wool. The bandage which retains the dressing in position should be applied firmly to check oozing. When the patient returns to bed the forearm is flexed to a right angle and supported on a pillow.

It is usually necessary to change the dressing the day after the operation. The drainage tube should be left in for two or three days.

## CHAPTER XXVI

### OPERATIONS ON THE CHEST

OPERATION FOR TUBERCULOSIS OF RIBS AND STERNUM; FOR TUMOURS OF RIBS; FOR ACUTE EMPYEMA; FOR CHRONIC EMPYEMA—*Estlander's Operation; Schede's Operation; Decortication.* PNEUMOTOMY: *For Abscess, for Gangrene; For Tumours and Cysts.* OPERATION FOR PULMONARY PHTHISIS. TRANS-  
PLEURAL OPERATIONS. OPERATIONS ON HEART AND PERICARDIUM: *Puncture and Drainage of Pericardium; Exposure and Suture of Heart; Cardiolytic.*

**Operation for Tuberculosis of Ribs and Sternum.**—*If the skin is still intact* an attempt should be made to excise in one piece the cold abscess and the portion of bone in which the primary focus of disease is situated.

In our experience this is best done by reflecting the skin, fascia, and muscle overlying the abscess in the form of a flap, and defining clearly the limits of the abscess and of the affected segment of rib, costal cartilage, or sternum as the case may be. The periosteum is then incised in the long axis of the rib, and separated from the bone, special care being taken while clearing the posterior aspect of the rib not to injure the parietal pleura. The rib is then divided with cutting forceps, and the operation completed by separating the intercostal muscles from the portion to be removed. The flap is then replaced and sutured in position without drainage.

In women it may be necessary to throw up the breast to gain access to the diseased focus.

When the abscess is too large to admit of complete

excision, or when sinuses are present, they must be laid freely open and seraped before the diseased segment of bone is excised. The wound is then purified, packed with gauze, and treated by the open method.

**Operations for Tumours of Ribs.**—As the pleura is

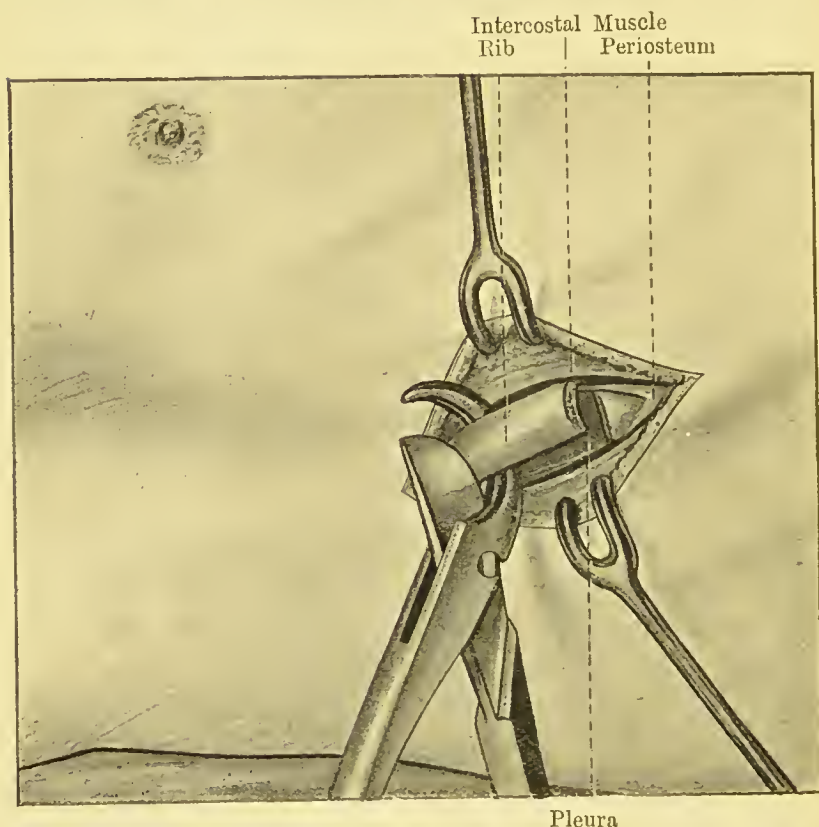


FIG. 152.—Operation for Acute Empyema.

frequently involved in tumours of the ribs, the operation is attended with considerable risk of pneumothorax. The operation, therefore, should if possible be performed with the aid of a differential pressure apparatus. If this is not available care must be taken that the pleura is opened by a small incision at first, and that as the opening is enlarged the wound is packed with a large

warm gauze compress. The lung may then be seized with forceps, pulled into the wound, and sutured to one edge of the opening, the sutures including the lung tissue as well as the visceral pleura, and the intercostal muscles as well as the parietal pleura.

The tumour is exposed by reflecting a U-shaped flap, with its base above and behind, or by a linear incision parallel with the ribs, according to the size and disposition of the growth. The soft parts, including muscle, having been reflected, the ribs to which the growth is adherent are defined and divided subperiosteally well beyond the limits of the tumour. If the pleura is implicated, and has to be opened, it is dealt with in one or other of the methods mentioned above. If a large opening has been made in the pleura the lung should be sutured all round, and any air left in the cavity withdrawn by means of an aspirator, before the external wound is closed. Provision should be made for draining the external wound, but not the pleural space.

**Operation for Acute Empyema.**—Before the incision is made the skin should be pulled up slightly over the rib to be resected, to ensure that, when the chest falls in after withdrawal of the pus, the opening in the soft tissues will be opposite the opening through the rib. The incision, which in cases of generalised empyema is best made over the seventh, eighth, or ninth rib in the mid- or posterior axillary line, and in the long axis of the rib, is carried down to the bone, dividing the periosteum freely (Fig. 152). The periosteum is then raised all round with a curved separator, care being taken of the intercostal vessels, which run in the groove on the under edge of the rib. With bone forceps a portion of rib about an inch and a half long is resected. The pleura is opened by pushing a director through it, and the finger is introduced through the opening thus made. Before the pus escapes, the cavity should be explored

with the finger to determine its extent and the condition of the lung. The pus is allowed to flow out slowly, in order that the heart and lungs may gradually accommodate themselves to the altered conditions of pressure within the thorax. It is not advisable to scrape the walls of the cavity, and irrigation is to be avoided unless the pus is very foetid. When irrigation is employed, care must be taken that the fluid is at body temperature, and that the outflow is as free as the inflow, so that there may be no accumulation of fluid, which by its weight may impede the action of the heart and lungs. Neglect of these precautions has led to serious, and in some cases to fatal, results.

Two large-sized rubber tubes are introduced side by side so that they project about a quarter of an inch into the pleural cavity; only that portion of each tube which projects within the pleural cavity should be perforated, so that the pus is carried past the wound in the parietes without contaminating it unduly. The advantage of two tubes is that the risk of blockage is diminished, and that, at the subsequent dressings, one tube can be removed at a time, the other keeping the wound open and facilitating re-introduction. The outer end of each tube should be transfixed with a large safety-pin to prevent its being sucked into the pleural cavity during inspiration. We have found Wilson's double-flanged empyema tube satisfactory. Hogarth Pringle recommends that if the lung does not show signs of expanding with the first few coughing efforts, the adhesions between the two pleural surfaces should be freely separated with the finger or with a blunt instrument, more ribs being resected if necessary to permit of the adhesions being reached.

**Operation for Chronic or Old-standing Empyema with Infected Sinuses.**—The object of this operation is to remove a sufficient amount of the chest wall to admit of



the parietes falling in sufficiently to lead to obliteration of the cavity. It follows, therefore, that the method selected will vary with the size and position of the cavity.

*Estlander's Operation* is suitable for cavities of limited extent. It consists in making a vertical incision over the cavity, dissecting back the soft parts to expose the ribs forming its outer wall, and resecting subperiosteally a sufficient length of each of these to allow the soft parts to fall in.

*Schede's Operation*.—This method is called for in more extensive cavities. A curved incision maps out a large horseshoe-shaped musculo-cutaneous flap, which is raised off the ribs, from the second or third to the ninth or tenth according to the size of the cavity. The ribs are then excised subperiosteally, after which the intercostal muscles with the thickened parietal pleura are removed, the intercostal vessels being secured as they are divided. The visceral pleura is scraped with a sharp spoon, and the musculo-cutaneous flap replaced and sutured in position.

Depage's modification of this method is less severe. It consists in making the incision through the soft parts, dividing the ribs and parietal pleura, securing the intercostal vessels as they are cut, and throwing up the whole chest wall as a flap. The ribs are then resected subperiosteally from the inner aspect of the flap, and the soft parts folded back into position.

**Decortication of the Lung**.—When the lung is firmly bound down in the vertebral groove and is incapable of expansion, the thickened visceral pleura should be stripped from it—*Decortication* (Fowler; Delorme).

The cavity is laid freely open, either by throwing up a U-shaped musculo-cutaneous flap, or by a longitudinal incision in the mid-axillary line, and after all the granulation tissue has been scraped away with a sharp spoon,

an incision is made through the visceral pleura until the lung tissue is exposed. The pleura is dissected off from above downwards as a flap, special care being taken that the thickened fibrous tissue at the angles of reflection between the visceral and the parietal pleura is freely removed, so that the exposed lung tissue may readily expand. The musculo-cutaneous flap is then replaced in contact with the raw lung surface, to which it may be stitched (Goldmann).

**Operation for Abscess or Gangrene of Lung.—Pneumotomy.**—The site of the diseased focus having been determined by clinical means and confirmed by the use of an exploring needle, an incision is made along the rib which corresponds to the lowest level of the abscess. A portion of this rib, about three inches in length, and, if necessary, of one or two ribs higher, is excised subperiosteally. A continuous circular suture is then introduced to bring together the parietal and visceral layers of the pleura round the area to be opened, and so to prevent the entrance of air or pus into the general pleural cavity. The pleura is now incised, the lung tissue divided with the thermo-cautery, and the abscess cavity emptied. If it is necessary to enlarge the wound in the lung to admit of the escape of gangrenous masses, this should be done with a blunt instrument or by introducing a pair of forceps and expanding the blades. The cavity in the lung is then packed with gauze or drained by means of tubes. Irrigation is to be avoided on account of the risk of disseminating the infection by way of the bronchi.

**Operation for Tumours and Cysts of the Lung.**—In the treatment of *hydatid cysts* which have become adherent to the thoracic wall, it is only necessary to resect a portion of rib and incise and pack the cavity, or if possible remove the cyst.

In the case of a *malignant tumour*, the growth has to

be excised and the healthy lung tissue sutured to the edges of the wound to prevent its collapse.

**Operation for Pulmonary Phthisis.**—In cases of unilateral apical phthisis, attempts have been made to favour collapse of the affected portion of the lung by resecting portions of several of the upper ribs.

Friedrich recommends the making of a large U-shaped musculo-cutaneous flap from the side of the chest, resection of the upper five or six ribs with the periosteum covering their outer aspects but leaving the retro-costal layer of periosteum, and replacement of the flap. Freeman has found that the falling in of the chest wall is hastened and increased by the application of a spiral truss so adapted as to exert pressure on the upper part of the front of the chest after resection of portions, two or three inches long, of the second, third, and fourth ribs below the clavicle with division of the cartilage of the first rib, as advised by Macewen.

**Operation for Emphysema.**—To diminish the size of the thoracic cavity and to restore the mobility of its walls, Freund (1859) recommended resection of portions of the upper ribs and costal cartilages. A curved incision, with its convexity towards the sternum, is made, exposing the cartilages from the second to the sixth inclusive. From two to three inches of bone and cartilage are excised from each rib, the periosteum being also removed or destroyed to prevent re-formation.

**Transpleural Operations.**—It is convenient to describe here the procedure followed when it is necessary to open an abscess or hydatid cyst in the upper part of the liver or a subphrenic abscess by traversing the pleural cavity.

The position of the lesion having been determined by the use of an exploring needle, an incision is made in the line of the seventh or eighth interspace, with its centre approximately in the mid-axillary line, dividing the skin and subcutaneous fascia, and the

underlying fibres of the latissimus dorsi, external oblique, and serratus magnus muscles (Fig. 153). The edges

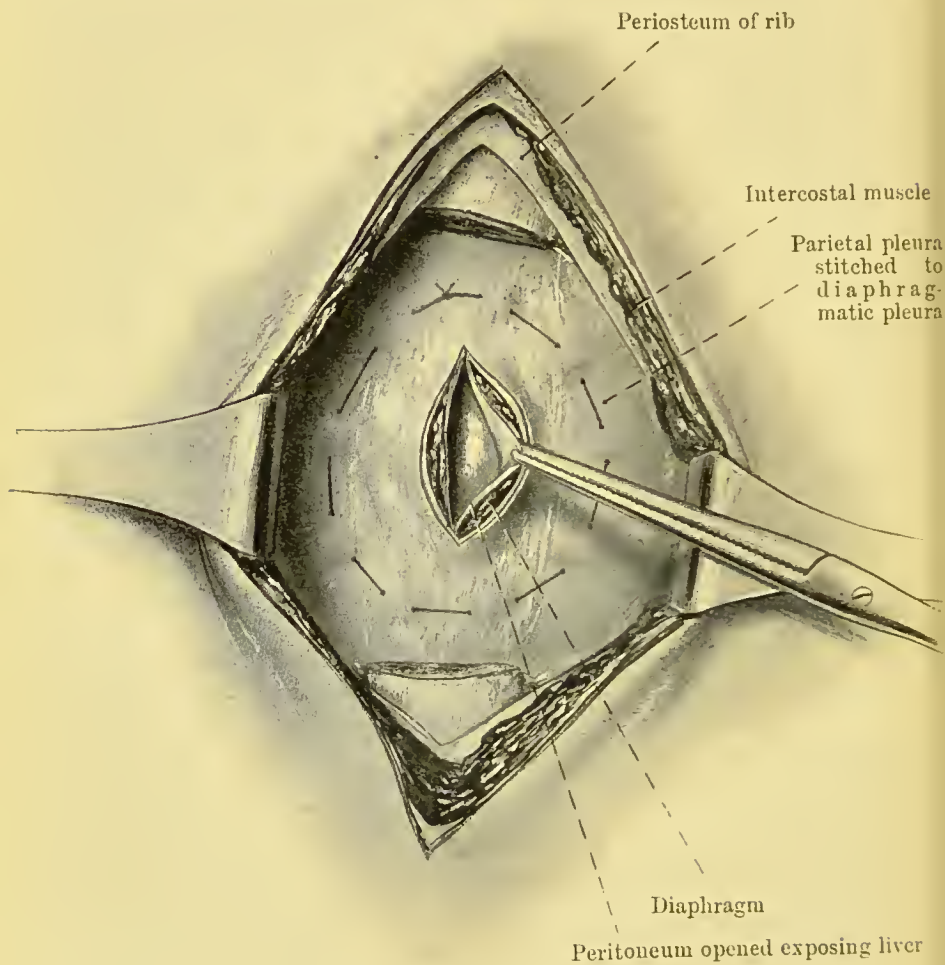


FIG. 153.—Exposure of Liver by Transpleural Route.

of the wound are retracted so as to expose the two adjacent ribs, and a portion of each, about 3 inches long, is excised subperiosteally, care being taken not to injure the pleura in so doing. To prevent the entrance of air,



blood, or pus into the pleural cavity during the subsequent steps of the operation, the portion of the pleural space to be traversed is shut off from the rest by introducing, with a large, curved, round needle, a continuous circular suture so as to approximate the costal to the diaphragmatic pleura. The stitches are passed through the intercostal muscles as well as through both layers of the pleura, and at each end of the divided ribs through the periosteum also. The costal layer of the pleura is then incised sufficiently freely to expose the diaphragmatic layer, which is recognised by its bluish, glistening appearance. This, together with the diaphragm, is incised, and if the underlying peritoneum is not adherent to the liver, a continuous circular suture is introduced to unite the parietal with the visceral layer of the peritoneum. This suture is seldom required, as the liver is usually adherent to the under surface of the diaphragm. The abscess cavity, or cyst, is then incised, emptied, and drained.

## OPERATIONS ON THE HEART AND PERICARDIUM

**Puncture and Drainage of the Pericardium.**—When filled with fluid, the pericardium usually distends outwards and to the left, hence the point at which it should be punctured is in the mammillary line in the fifth or sixth intercostal space (Curschmann).

When the fluid is purulent, a portion of the fifth rib should be resected (Gussenbauer).

**Exposure and Suture of the Heart** (Fig. 154).—An incision is made from the middle of the sternum outwards along the line of the sixth costal cartilage, dividing the skin and fasciæ and the attachment of the rectus abdominis to the cartilage. The fibres of the pectoralis major are then divided and held aside, and next the intercostal muscles attached respectively to the upper



and lower borders of the cartilage. The periehondrium is separated all round and the cartilage excised.

The internal mammary vessels are seen running obliquely across the space near to the edge of the sternum, and are seized and divided between forceps and

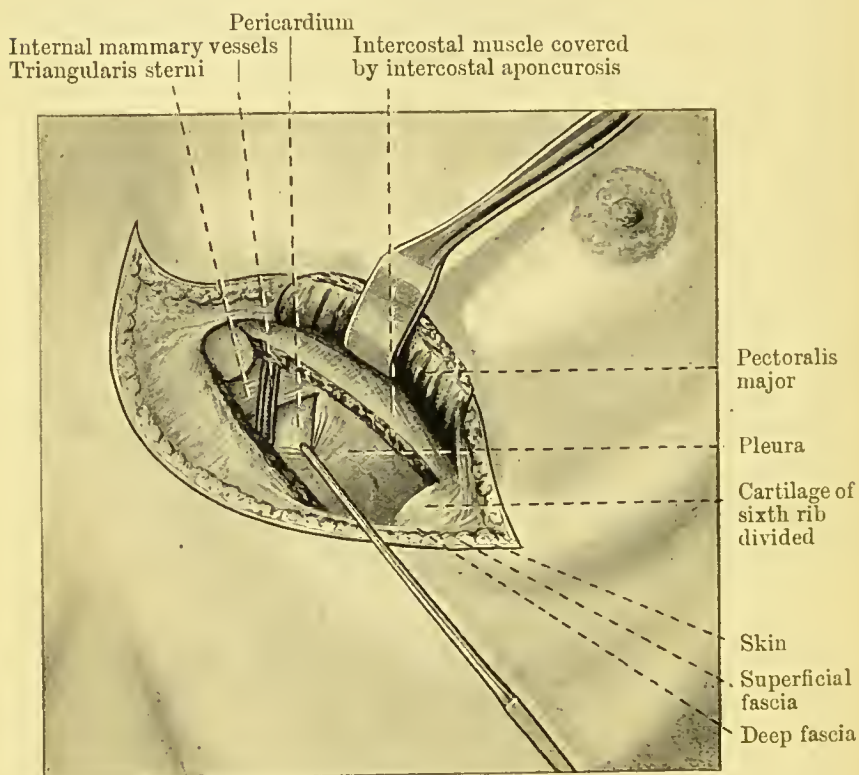


FIG. 154.—Exposure of Pericardium.

ligated. Underneath them, the triangularis sterni fibres are seen, and are hooked aside along with a layer of fat which indicates the position of the reflection of the pleura. The pleura is held aside, care being taken not to open it, and the pericardium exposed.

If the heart is seriously embarrassed by blood effused into the pericardial space, it may be relieved by incision of the pericardium and removal of clots.

To gain freer access to the pericardium and to admit of a wound in the heart itself being dealt with, the incision is now extended upwards along the middle of the sternum as far as the fourth or third costal cartilage, and from the upper end of this wound an incision is carried transversely outwards dividing the fibres of the pectoralis major and exposing the underlying rib. The intercostal muscle is separated from the upper border of the rib exposed. The costal cartilages are then divided from below upwards close to the sternum, care being taken that the subjacent pleura is held well aside. After all the cartilages have been divided, the whole flap is folded out, and the cartilages in its base are broken at their junction with the ribs.

The whole pericardium is thus exposed, and can be opened as freely as is necessary. The wound in the heart is closed with interrupted sutures of fine silk or catgut, care being taken not to enter the cavity, lest oozing take place along the tracks of the stitches.

All clots having been removed from the pericardial space, the pericardium is sutured and the external wound closed and drained.

**Cardiolysis.**—This operation is designed to relieve the heart from the effects of extensive pericardial adhesions. The heart is exposed in the manner above described, and the adhesions dealt with. Owing to the risk of damaging the heart wall in separating the adhesions, Brauer recommends that the thoracic wall be mobilised in front of the heart. The pericardium is exposed, by reflecting a flap of skin and muscle, resecting portions of several ribs and the adjacent part of the sternum, including the posterior layer of its periosteum. The musculo-cutaneous flap is then replaced and sutured in position.

## CHAPTER XXVII

### SURGERY OF THE ABDOMEN AND PELVIS

ABDOMINAL INCISIONS: *Median; Lateral.* ATTITUDE OF PATIENT. PROTECTION OF PERITONEUM. USE OF CLAMPS. CLOSURE OF ABDOMINAL WOUNDS. TECHNIQUE: Sutures—*Lembert Suture; Czerny-Lembert Suture; Mattress Suture; Purse-string Suture.* ANASTOMOSIS BETWEEN VISCERA: *Lateral Anastomosis; Termino-lateral Anastomosis or End-to-side Junction; Invagination Method.*

#### ABDOMINAL INCISIONS

ABDOMINAL incisions made for purposes of exploration or to expose centrally placed viscera, such as the pylorus, are generally made in or near the middle line. To reach viscera situated to one side of the middle line, such as the cæcum, the gall bladder, or the spleen, lateral incisions are employed. Freer access may sometimes be obtained from the combination of a median with a lateral incision.

**Median Incisions.**—Incisions made in the middle line, or close to it, have the great advantage that they do not divide any of the motor nerves supplying the abdominal muscles. Above the umbilicus (Fig. 155, *a*), the median incision divides skin, fat, and the dense aponeurosis of the *linca alba*; below the umbilicus (Fig. 155, *b*), after the aponeurosis has been divided, the recti muscles are usually seen in close contact, and must be separated by blunt dissection. The transversalis fascia is not always recognisable as a separate layer. The extra-peritoneal fat and peritoncum are next pinched up with the aid of two

catch forceps and carefully incised between them until the peritoneal cavity is opened; two fingers of the left hand may now be inserted in order to protect the viscera, while the peritoneum and fat are divided throughout the whole length of the wound.

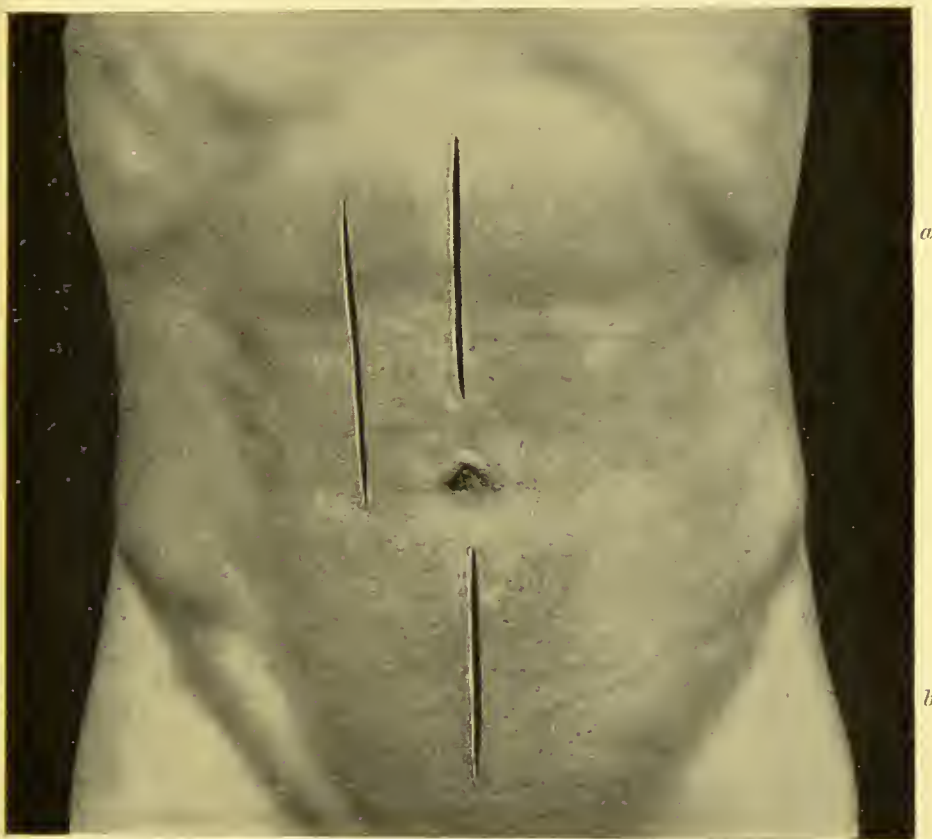


FIG. 155.—Abdominal Incisions.

When a median vertical incision must be prolonged so as to encroach on the umbilicus, either this structure should be excised or the incision should be carried round one side of it.

**Incisions close to the Middle Line.**—When the incision is made over one or other rectus muscle (Fig. 155, *c*), the anterior layer of the sheath is divided vertically, and the

muscle is displaced bodily outwards and retained in that position by a retractor; the posterior layer of the sheath, the fat and parietal peritoneum, are then divided in the line of the original incision. In closing the wound after the posterior layer of the sheath has been sutured, the



FIG. 156.—Abdominal Incisions.

rectus is allowed to slip back into its original position and is retained there by one or two points of suture.

**Lateral Incisions.**—Lateral incisions should run parallel with the lines of the nerves supplying the muscles of the abdominal wall. They are necessarily, therefore, oblique or horizontal. After the skin and superficial fascia have been divided, the exposed portion of the external oblique,



whether muscular or aponeurotic, is split in the line of its fibres, that is, in a direction downwards and inwards, and the edges are held aside with retractors. The internal oblique, which is now exposed, is split in the line of its fibres, almost horizontally inwards, and, its edges being retracted, the transversalis muscle is exposed and is similarly dealt with. The method of opening the abdomen by separation between the fibres of the respective muscles was devised by M'Burney, and is often called the "gridiron method." The peritoneal cavity is opened with the same precautions as before, and the parietal peritoneum is slit up the whole length of the wound.

When a lateral incision requires to be prolonged over the costal margin, the cartilage concerned may be cut across in the line of the incision, provided care is taken not to injure the parietal pleura. If a lateral incision alone does not give sufficient access, it may be prolonged horizontally inwards across the rectus as far as the middle line, dividing both the sheath and the muscle itself; this entails no interference with the innervation of the muscle, as its different segments are innervated separately and horizontally. Above the level of the umbilicus, the terminal fibres of the transversalis muscle run horizontally inwards behind the rectus.

Long incisions at the outer border of the rectus—that is, in the semilunar line—have the disadvantage that they entail the risk of interfering with the innervation of the muscle.

The combination of a lateral oblique incision with a median vertical one, forming a flap as shown in Fig. 156, *a*, is another means of obtaining more extensive access without damaging the nerve supply to the muscles.

In the lower part of the abdomen, when the operation is directed towards the internal abdominal ring, the vermiform appendix, the uterus, or the urinary bladder,

the skin incision may be made in the inter-spinous fold, that is, a natural fold which is frequently seen running between the two anterior superior iliac spines (Lanz).

**Attitude of Patient.**—In most abdominal operations the horizontal dorsal position, or one in which the trunk inclines slightly downwards towards the head, suffices, but in certain operations, and especially in those within the pelvis, the Trendelenburg position, in which the patient lies on the back on a plane inclined about  $45^{\circ}$ , with the pelvis raised and the feet and legs hanging over the end of the table, affords better access, as the intestines are displaced by gravity towards the diaphragm. By placing a firm sand-bag or a specially constructed cushion under the lower ribs or in the hollow of the back, such organs as the liver and gall bladder or the kidneys may be projected forward and rendered more accessible.

**Protection of the Peritoneum.**—In all operations in which the stomach or intestine or other hollow viscus has to be opened, it is of great importance to prevent the contents from soiling the peritoneum or the abdominal wound. The risk from leakage is greatly minimised if the viscus can be completely withdrawn from the abdominal cavity. This having been done, it is packed round with large pads of gauze wrung out of hot saline solution. To prevent the risk of such pads being left in the abdomen, a piece of broad tape, six inches long, is firmly stitched to each, and after the pads have been placed in position, the tape is secured with artery forceps. The packing should be done systematically, and it is an advantage to employ two tiers of swabs. "Those first introduced are of large size, are well packed into position, and completely surround the field of operation. They remain unchanged throughout. On the top of this outer barrier of large swabs a layer of smaller ones is placed. These are changed one by one as soon as soiled" (Moynihan).

**The Use of Intestinal Clamps.**—Two kinds of clamp are used in gastro-intestinal surgery: (1) *crushing clamps* or *enterotribes*, which are designed to compress the tissue within the grasp of the blades so that it is reduced to a thin band which can easily be secured by a ligature before being buried by superimposed rows of sutures (Fig. 168). This form of clamp is particularly useful in such operations as gastrectomy and enterectomy, in which the divided ends of the gut are to be completely occluded, and the continuity of the intestinal tract re-established by lateral anastomosis. (2) *Occluding or retention clamps* are intended to compress the bowel, to control the bleeding from its wall when it is divided, and to prevent the escape of its contents. The practice of different surgeons varies widely with regard to the use of occluding clamps; some employ them in nearly all operations on the gastro-intestinal tract, others dispense with their use as far as possible, relying on the hands of a skilled assistant.

**Closure of Abdominal Wounds.**—To obtain a scar which will not afterwards stretch and favour the development of a hernia, it is not only essential to plan the incision so that the nerves and muscles of the abdominal wall are preserved in their functions, but to stitch the different layers separately with suture material which will not become absorbed before firm union has taken place. Before these sutures are introduced, however, deep stitches of silkworm gut are passed through the whole thickness of the wall with the aid of long, straight, bayonet-pointed needles (Fig. 157), but are not tightened and tied until all the other stitching is completed. To ensure that these deep stitches shall be inserted symmetrically and at regular intervals, their position should be indicated by scratching the skin with a needle across the track of the proposed incision before it is made. As through-and-through sutures, if tied tightly, tend to cut the skin, it is advisable to surround them with rubber tubing, or to

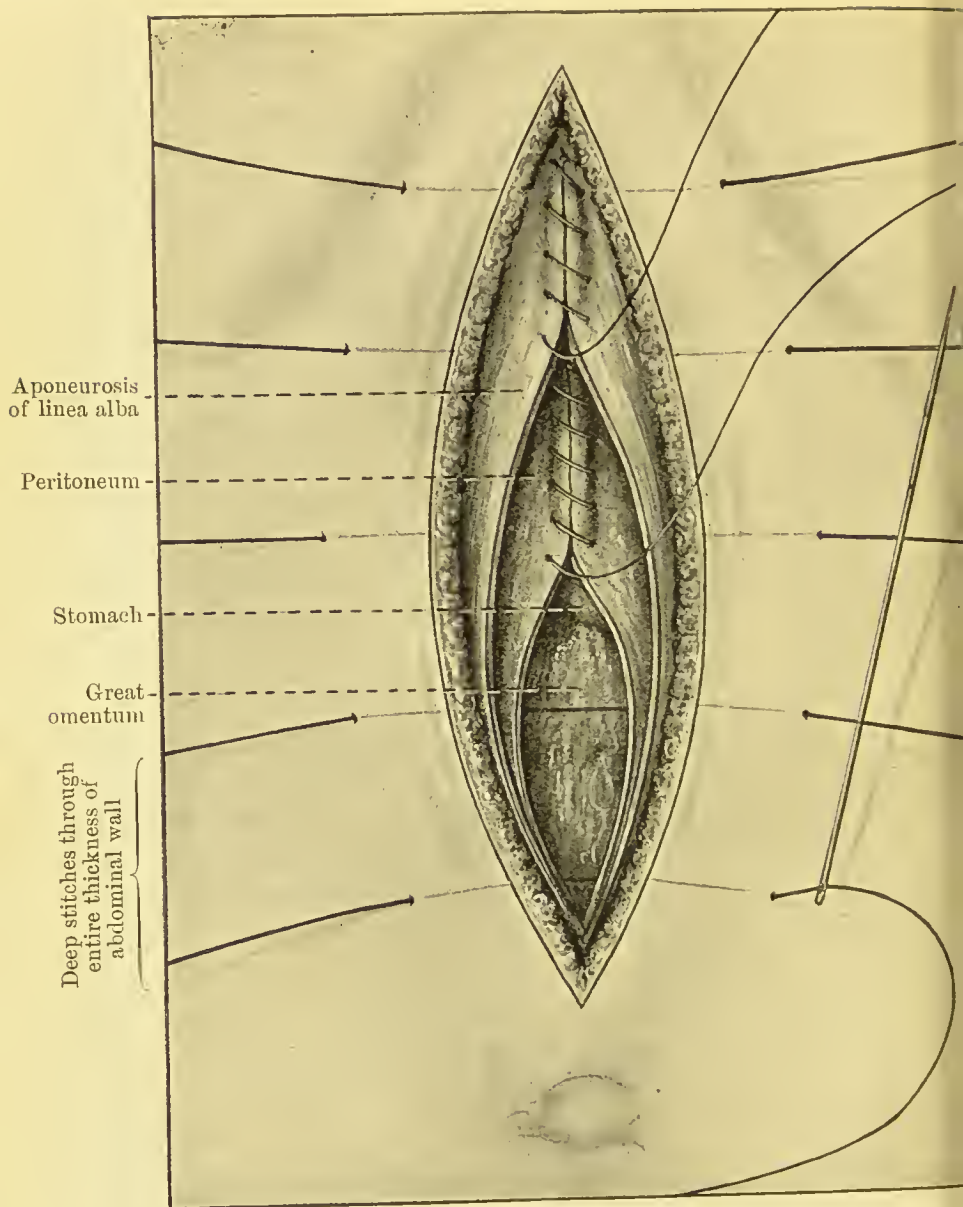


FIG. 157.—Closure of Wound in Middle Line above Umbilicus.

tie them over a roll of gauze; we prefer to tie them loosely.

The first suture, which unites the peritoneum and



fascia transversalis, is introduced with a round needle carrying stout catgut, the loose ends of which are grasped with catch forceps; it is preferably continuous, and if, as sometimes happens, these structures tend to tear, the posterior lamella of the sheath of the rectus should be included. As the posterior lamella of the sheath is absent below the fold of Douglas, at this level some of the substance of the rectus muscle should be included. To facilitate the insertion of the first tier of sutures, the edges of the parietal peritoneum are seized with forceps and pulled away from the abdominal contents. Should the viscera tend to protrude, they are retained by a thick layer of moist gauze, stiffened up by an intervening layer of rubber. We have found a large broad dinner-spoon useful in protecting the viscera while suturing the peritoneum. The next series of sutures includes the muscles and aponeurosis; a sharp-edged needle is usually employed, with a double strand of thick catgut; each divided muscle or aponeurosis is sutured separately, and if a continuous suture is employed there is a considerable saving of time.

It is more important to suture accurately an aponeurosis, such as the sheath of the rectus, than the muscle. In the case of the external oblique aponeurosis, if it is unduly lax, its edges should be made to overlap, thus giving a broader surface for union. It is advisable to suture the superficial fascia, as this tends to prevent the subsequent stretching of the cutaneous scar. When the use of a drainage tube is called for, it is preferable, although not always convenient, to have it emerge through a separate opening in the abdominal wall. To retain the dressings and afford support, a many-tailed bandage is better than a roller bandage, because it can be undone without lifting the patient; it is prevented from being displaced by bringing the two lowest ends of the bandage round the root of each



lower limb, and the two highest over the shoulders like braces. Some prefer to hold the dressings in place by long strips of adhesive plaster.

## TECHNIQUE OF ABDOMINAL SURGERY

**Sutures.**—The technique of suturing the stomach and intestine must be thoroughly mastered, and, as suggested by Binnie, the manipulations may be conveniently practised on the fresh intestine of the pig. Fine round needles, curved or straight, are employed, and the point must be very sharp, so that it easily transfixes the wall of the viscus.

The best suture material to employ is the finest catgut or silk. Some surgeons prefer linen thread. The stitches must be inserted with a light, steady hand, avoiding visible blood vessels.

To prevent leakage of the contents and obscuring of the parts by bleeding, it is a common practice to control hollow viscera, such as the stomach or intestine, with suitable clamp forceps, the blades of which are surrounded by rubber tubing.

*The Lembert Suture.*—For the union of divided parts of the stomach and intestine, the suture introduced by Lembert in 1826 still retains its premier position. Its success is due to the fact that when irritated surfaces of the peritoneum are brought into contact, they become gummed together by lymph exudate and are united to one another by connective tissue more rapidly than any of the other elements.

About a quarter of an inch from the edge of the wound the needle pierces the serosa, the muscularis, and part of the submucosa, and, without entering the lumen of the bowel, emerges again through the serosa close to the edge of the wound; on the opposite side it enters close to the edge of the wound and emerges a quarter

of an inch farther away (Fig. 158). The mucous membrane is not touched, but when the stitch is tightened and the knot tied (Fig. 159) the mucous membrane disappears, being invaginated into the lumen of the bowel. The

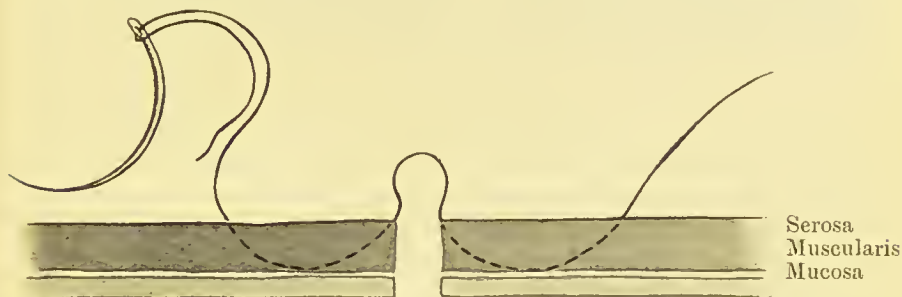


FIG. 158. —Diagram of Lembert's Suture being introduced.

interrupted form of the Lembert suture is seldom employed, as the bowel can be closed with greater rapidity and equal security by the continuous form.

*The Czerny-Lembert Suture.*—Save that it does not control bleeding from the mucous and submucous coats, the continuous Lembert suture would suffice for every

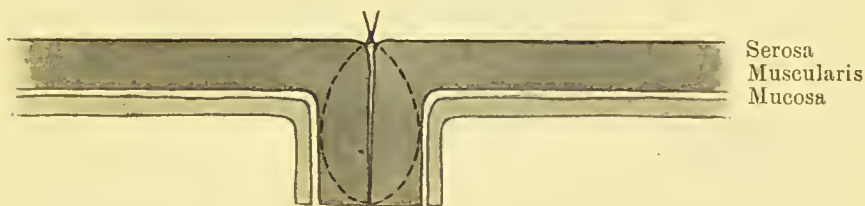


FIG. 159. —Diagram of Lembert's Suture completed.

purpose. It is necessary, therefore, to introduce two rows or tiers of sutures: an inner, continuous, blood-controlling suture, passing through the mucous membrane only or through all the coats—the Czerny addition—and an outer Lembert invaginating suture (Fig. 160).

The *Mattress Suture*, as described by Halsted, is intended to approximate the serous coats; it consists of

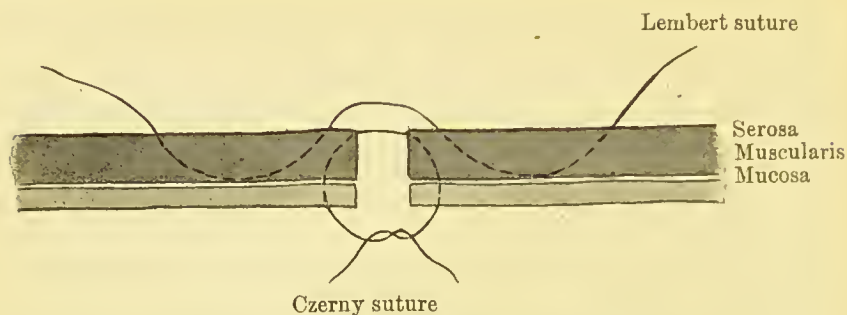


FIG. 160.—Diagram of Czerny-Lembert Suture.

two parallel Lembert stitches connected on one side of the wound by a loop, leaving the two ends free on the

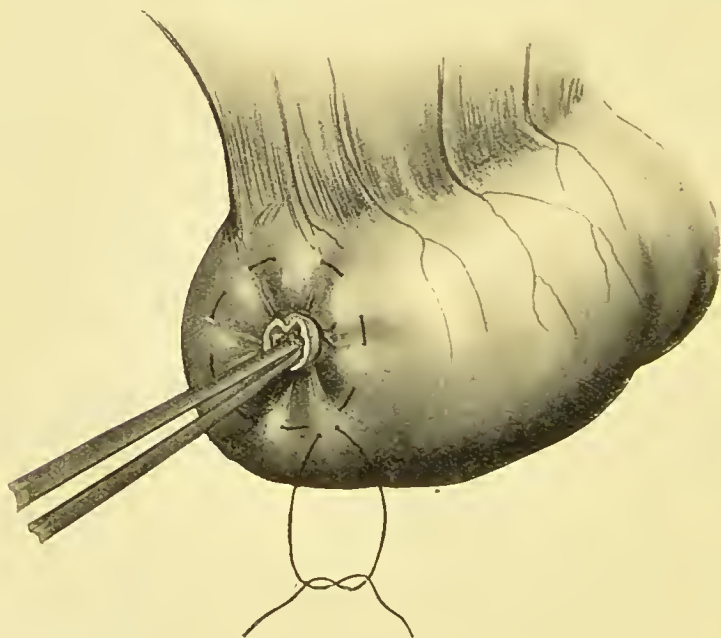


FIG. 161.—Purse-string Suture introduced.

opposite side; when these ends are tied, the peritoneal surfaces are drawn together very accurately.

The *Purse-string Suture* is made by carrying a continuous Lembert suture circularly round an area of bowel, for example, the stump of the appendix, a perforation,

or the divided end of a coil of intestine, so that, when it is tightened, the enclosed area is puckered in, and the serous surfaces brought into apposition (Fig. 161).

Numerous modifications of these sutures have been adopted for special purposes, and many complicated methods of stitching have been devised, but these are seldom called for and have no advantage over the simpler forms.

**ANASTOMOSIS BETWEEN VISCERA.**—In the course of operative procedures on the gastro-intestinal canal, it is frequently necessary to form an artificial junction between two viscera or between two parts of the same viscus, or to re-establish the continuity of the tube. The methods of establishing such anastomoses vary according to circumstances.

**Lateral Anastomosis.**—The term “lateral anastomosis” is employed when a side-to-side junction is made between two segments of the alimentary canal. This method has to a large extent superseded “end-to-end” suture in re-establishing the continuity of divided bowel. It is more easily and rapidly performed, the line of suturing can be more certainly rendered water-tight, and it admits of a larger opening of communication being made with less risk of subsequent cicatricial narrowing. It is widely applicable, and is the method of choice for establishing a communication between different segments of the canal, for example, between two pouches of the stomach in hour-glass contraction of that organ—*gastro-gastrostomy*; between a coil of intestine above an obstruction and one below—*entero-anastomosis*; between the small and large intestine—*ileo-colostomy*, and between two parts of the colon—*colo-colostomy*.

Each of the two segments to be united is secured in a separate clamp or between the blades of a treble-bladed clamp, such as Roosevelt's, as shown in Fig. 162; or they may be held in apposition by an assistant, who

firmly grasps the bowel so as to prevent escape of its contents.

The approximated peritoneal surfaces are united by means of a continuous stitch known as the "posterior serous suture." The viscera on each side of the suture line are then opened with a narrow-bladed knife and the incision is enlarged if necessary with scissors, or the serous and muscular coats may be divided with the knife and the mucous and submucous coats with the cautery.

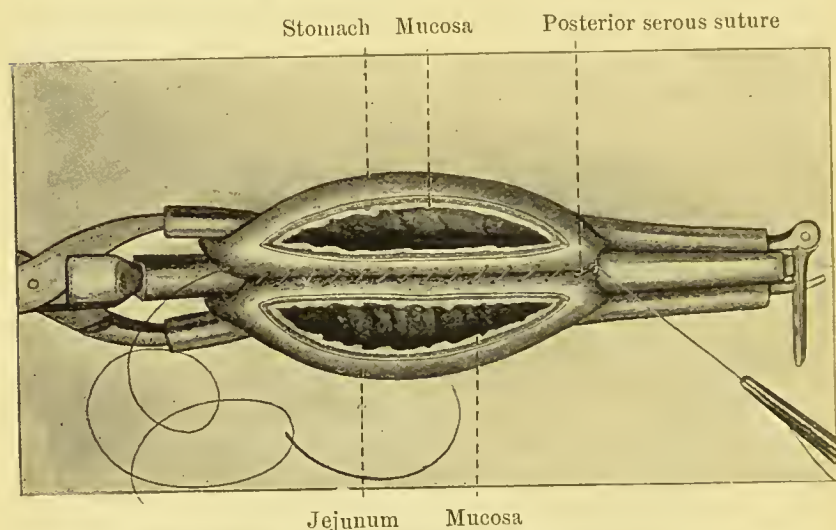


FIG. 162.—Lateral Anastomosis between Stomach and Intestine (Gastro-enterostomy). 1st stage.

It is sometimes an advantage to divide first only the serous and muscular coats and to introduce a second row of sutures uniting them before dividing the submucous and mucous coats. Any visceral contents are mopped up with small pieces of gauze held in forceps. A continuous suture is then passed through all the coats of both loops, beginning at one end on the posterior surface, and when the other end is reached, the same suture is carried along the anterior surface to the starting-point (Figs. 162 and 163). In this way the lumen of the bowel is closed.



To prevent eversion of the mucous membrane along the anterior surface, the needle may with advantage be used so that it always passes from within outwards (Fig. 165).

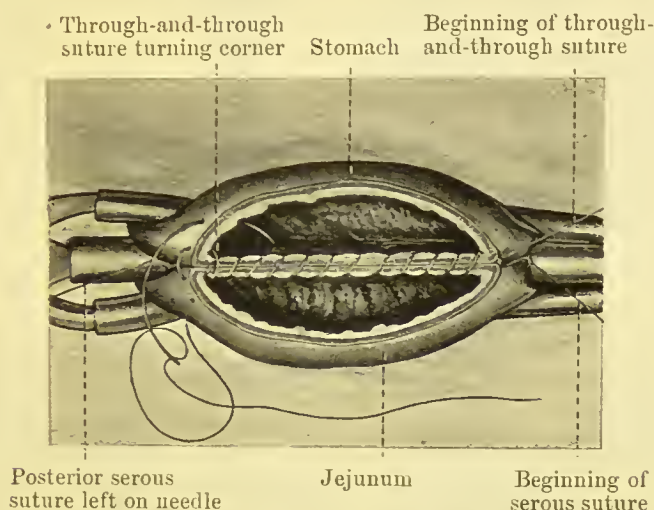


FIG. 163.—Lateral Anastomosis. Further stage.

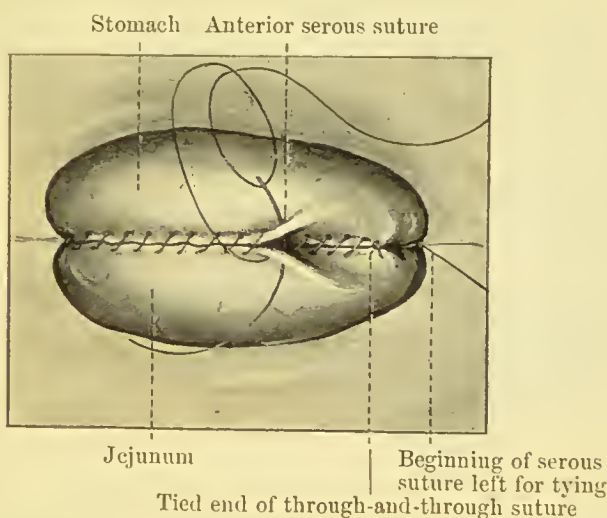


FIG. 164.—Lateral Anastomosis almost completed.

The viscera are now cleaned with gauze wrung out of saline solution and the clamps removed; if there is bleeding at any point, an additional suture is inserted.

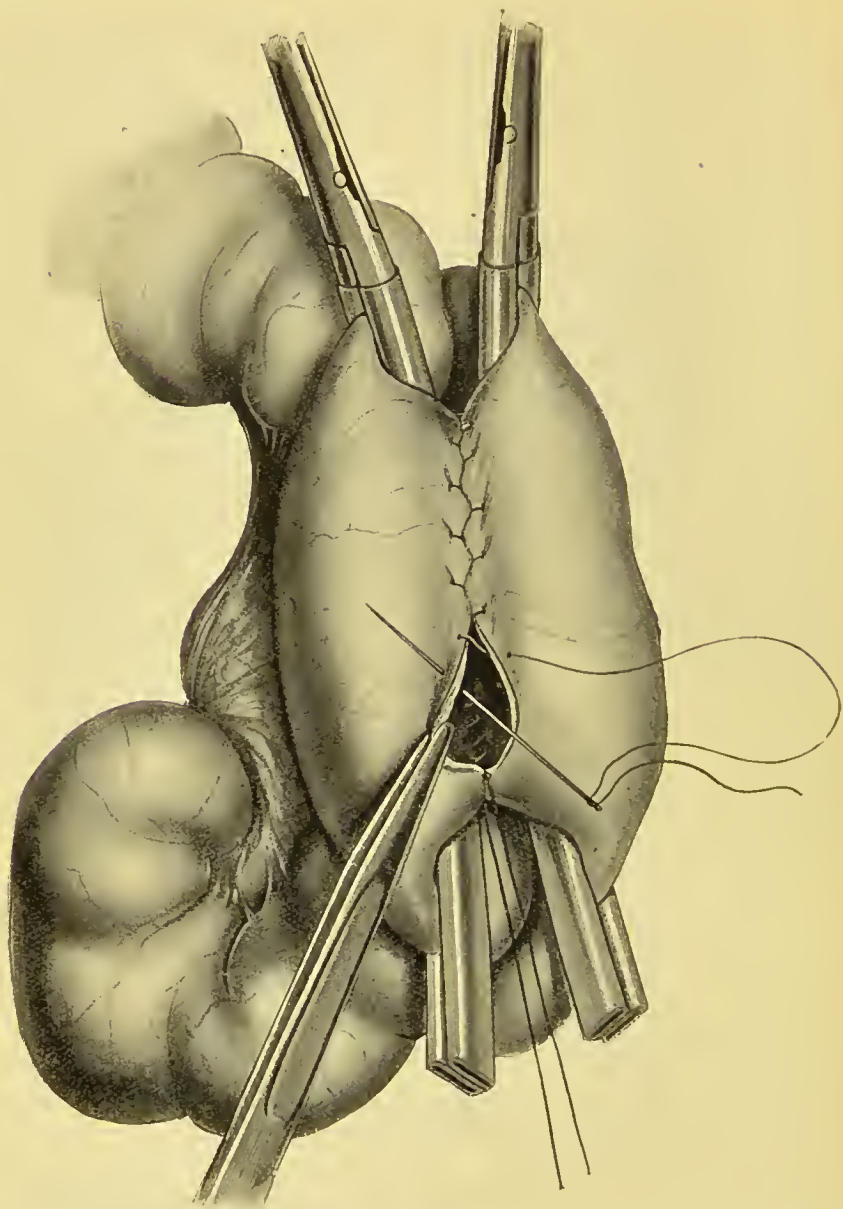


FIG. 165.—Anastomosis between stomach and intestine. Through-and-through suture being introduced from within outwards to prevent eversion of mucosa.

The procedure is then completed by approximating the peritoneal surfaces along the front by a continuous

Lembert suture—"anterior serous suture." If there is a free edge of omentum or mesentery available, it may be fixed over the line of suture to give additional security.

When the junction must be effected rapidly, or when the bowel cannot be brought out at the wound for purposes of suture, for example in uniting two loops of bowel in the lower part of the pelvis, one or other of the mechanical aids to anastomosis may be employed. Of these there is a considerable variety. It is here

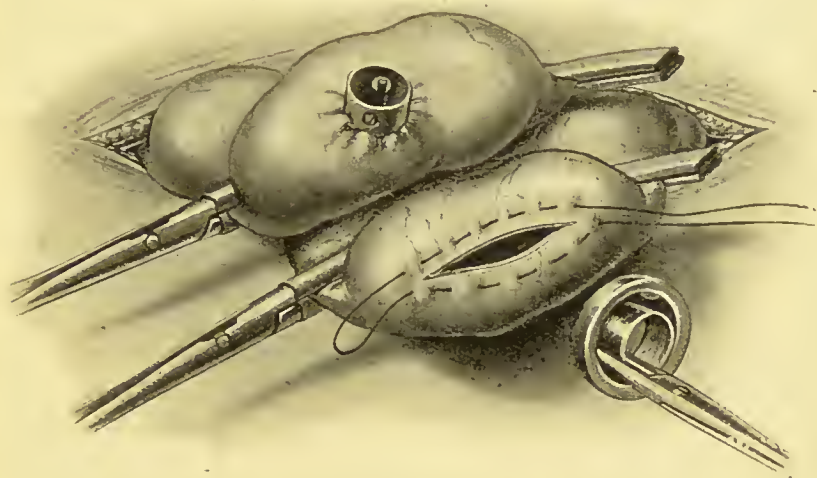


FIG. 166.—Lateral Anastomosis between two Coils of Small Intestine with the aid of a Murphy Button.

sufficient to describe the method of using the metal button devised by J. B. Murphy. This apparatus consists of two separable button-shaped segments from the centre of each of which projects a round metal tube, and is so constructed that these tubes fit into one another. When the two halves are pressed together, a spring in the one with the smaller tube—the "male segment"—causes them to become locked.

In employing Murphy's button, the central tube of each half is grasped with a Kocher's artery forceps as

shown in Fig. 166, or plugged with a cork on a suitable handle, and laid to one side till the other segment is prepared.

The loops of bowel that are to be united are brought out at the wound, emptied and clamped, and the surrounding parts packed off with gauze. A purse-string suture of fairly stout silk or catgut is inserted into the gut through all the coats opposite the attachment of the mesentery. A longitudinal opening is then made in the bowel with a knife or scissors, just large enough to admit the button. To avoid the risk of cutting the purse-string suture, its looped end should be left long, and both the open and the looped ends are pulled upon by the assistant. It is often preferable to make the opening at right angles to the long axis of the gut. Into each of the openings thus made, one half of the button is inserted as far as the flange, the purse-string suture is pulled tight and securely knotted round the central tube which projects beyond the suture. The forceps, or cork plugs, are then removed, and each segment of bowel containing its own half of the button is grasped with the fingers to prevent the button dropping into the lumen, and the projecting central tubes are pushed into one another and pressed together until they become securely locked. In this way the peritoneal surfaces of the two segments of bowel are brought into close apposition. If the co-aptation is not completely satisfactory, one or two additional sutures may be introduced. The serous surfaces soon unite, and in the course of eight or ten days the button becomes loose and is passed *per anum*. Sometimes it remains longer in position.

**Termino - Lateral Anastomosis or "End-to-Side" Junction.**—Termino-lateral anastomosis consists in implanting the proximal end of a coil of intestine which has been cut across into the lateral aspect of a lower



coil. The lower end of the divided segment is closed, with the result that the length of bowel between it and the new junction is completely excluded. Such an operation is performed for colitis and dysentery, the ileum being implanted into the pelvic colon, to prevent the contents of the small intestine from passing into the diseased segment.

The abdomen is opened in the middle line below the

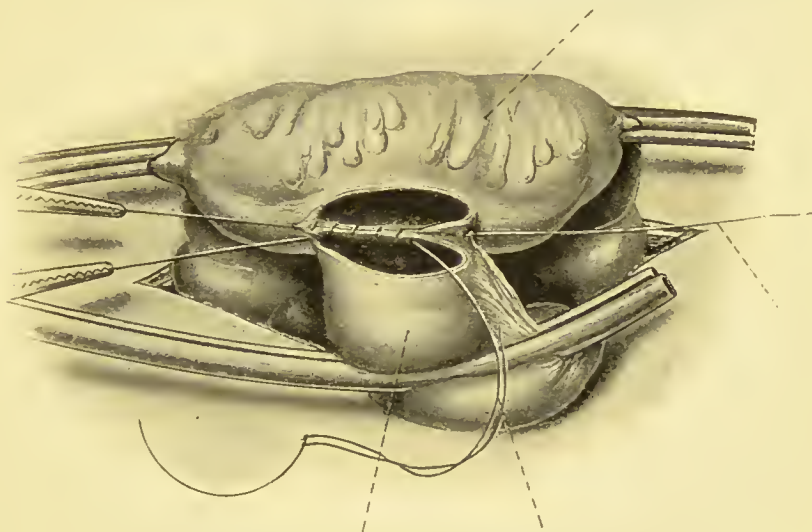


FIG. 167.—End-to-side Anastomosis by Suture.

Ileo-sigmoidostomy; the cut end of the ileum is being anastomosed with the pelvic colon.

umbilicus, and the lower end of the ileum identified. A coil from a foot to a foot and a half above the ileo-cæcal valve is selected, so as to obtain gut with a mesentery of sufficient length. The loop having been clamped at its base, the gut is crushed in the enterotribe, divided (Fig. 168), and the lower end ligated and invaginated with a purse-string suture. The sigmoid portion of the pelvic colon is now searched for and identified by tracing it into the hollow of the sacrum. The lowest part that is capable of being brought out at the wound is clamped,



FIG. 168.—(a) Crushing of the Bowel, a preliminary step to its Closure by Ligation.



(b) Closure of the Bowel by Ligation subsequent to Crushing.

and an incision made in the longitudinal band opposite the mesentery. The upper end of the ileum still secured in its clamp is now approximated to the opening in the

colon, and the junction is effected by the usual two tiers of suture, or with the aid of a Murphy button: so near the rectum, there need be no hesitation in employing a button for such an anastomosis. C. L. Gibson advocates end-to-end junction by a method of invagination (Figs. 196, 197, and 198).

## CHAPTER XXVIII

### OPERATIONS ON THE VERMIFORM APPENDIX

REMOVAL OF APPENDIX : *Interval Operation ; removal during Attack of Appendicitis ; when Abscess has formed.* APPENDICOSTOMY

#### REMOVAL OF THE APPENDIX

**The Interval Operation.**—The removal of the appendix between attacks—the “interval operation”—was introduced by Treves in 1887. It is now more frequently practised than any other abdominal operation.

*Incisions.*—Numerous incisions have been recommended to expose the appendix in the quiescent state, and the choice between them is largely a matter of personal preference.

The plan suggested by M'Burney and by Roux, of separating the different muscles in the direction of their fibres—the so-called *gridiron method*—admits of the appendix being removed through a comparatively small wound, but it has the drawback that the opening cannot conveniently be enlarged if the access is found to be insufficient.

The centre of the skin incision falls in the line between the anterior superior iliac spine and the umbilicus, and is roughly about two inches distant from the spine (Fig. 169, *b*). The aponeurosis of the external oblique is split in the direction of its fibres and held aside, and then the internal oblique and transversalis are similarly dealt with. The fascia transversalis and peritoneum are next picked up and incised.

The incision *through the sheath of the rectus* (Fig. 169, *a*), sometimes attributed to Battle, is made parallel with the linea semilunaris a little internal to the outer border of the rectus; the aponeurosis of the external oblique and the anterior layer of the sheath of the rectus are divided in the line of the skin incision, and



FIG. 169.—Incisions for Exposure of Vermiform Appendix.

- (*a*) Incision through Sheath of Rectus.
- (*b*) Incision of M'Burney and Roux.
- (*c*) Lanz' Incision.

the outer border of the rectus muscle is defined and pulled inwards. The transversalis fascia and peritoneum are divided in the same line, and in opening the peritoneal cavity, and especially in enlarging it downwards if this is required, care must be taken not to injure the deep epigastric vessels.

A third method, suggested by Lanz of Amsterdam,  
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consists in making the incision in the interspinous fold running inwards and slightly downwards from the anterior superior spine (Fig. 169, *c*); the muscles are separated as in the gridiron method of M'Burney.

The abdomen having been opened, the cæcum is

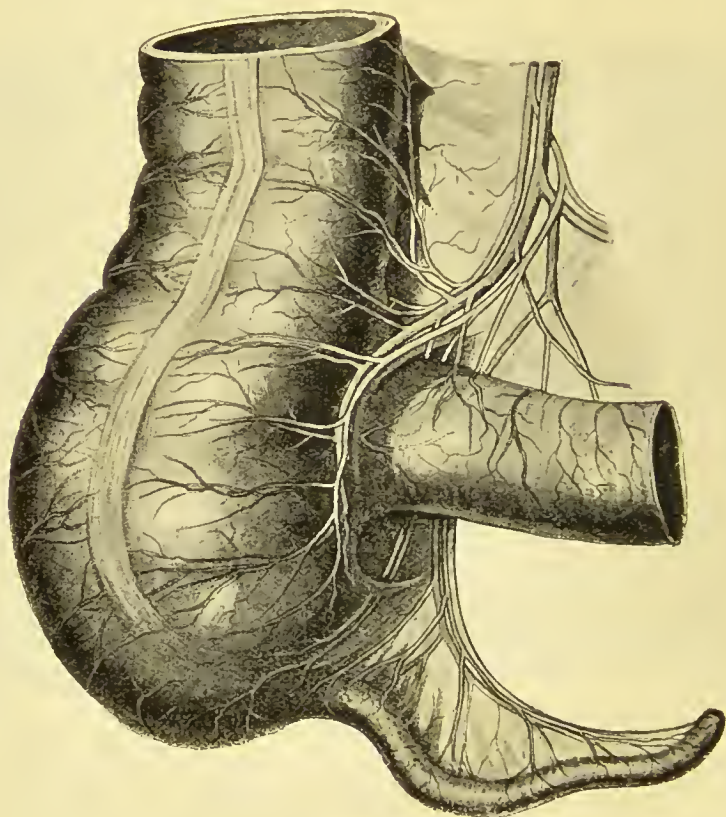
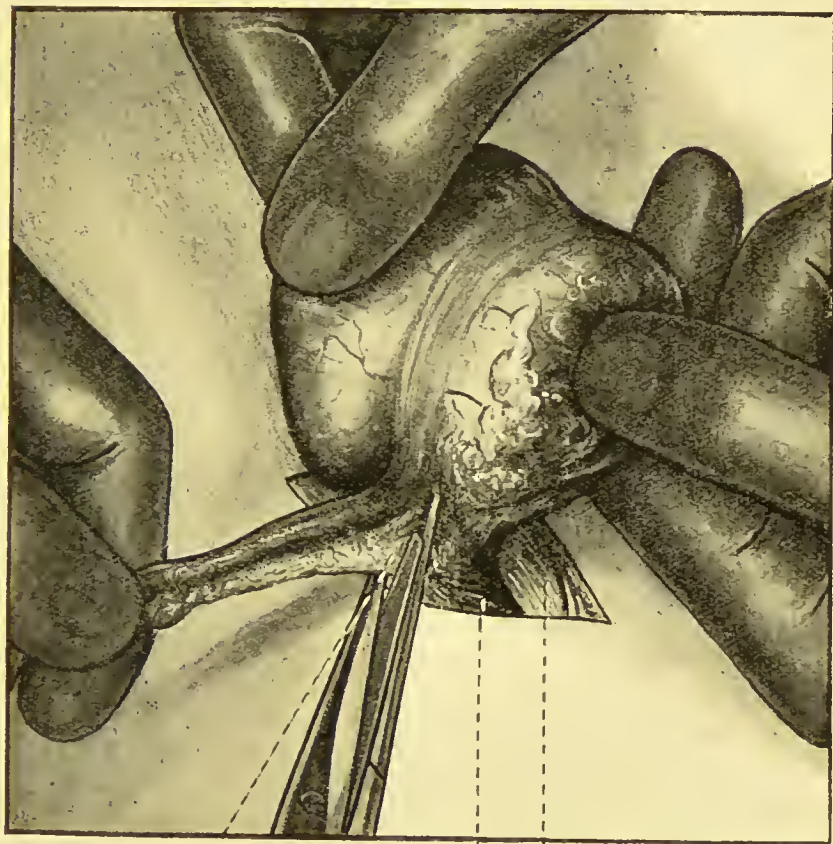


FIG. 170.—Normal Cæcum and Appendix (after Kelly).

sought for and pulled out at the wound, and its anterior longitudinal band is traced downwards until the root of the appendix is reached. In some cases the appendix presents at the wound; in others it is not to be found in its usual relationship with the cæcum, and has to be sought for in one or other of the peri-cæcal fossæ, from



which it may be difficult to remove it. Not infrequently it is embedded in the posterior wall of the ascending colon, or buried in adhesions which bind it to the ovary,



Division of mesentery  
of appendix

Internal oblique  
and transversalis  
muscles split

External oblique  
aponeurosis

FIG. 171.—Removal of the Vermiform Appendix, 1st stage.

the bladder, or the wall of the pelvis. When the parts are buried in adhesions, the general peritoneal cavity must be packed off with gauze before proceeding to separate it, in case a focus of infection is opened up. If the omentum is adherent over the appendix it should not be stripped off, but should be clamped, divided, and

ligated at a little distance from the appendix. In separating dense adhesions to other structures, which are perhaps unrecognisable at the moment, the adhesions should be stripped off the appendix by gauze pressure. Whatever its position and however complicated the adhesions, the appendix must be followed out until its tip is reached; otherwise there can be no guarantee of freedom from trouble in the future. In difficult cases we have often followed the plan adopted many years ago by Annandale, of first dividing the appendix near its junction with the cæcum, and then proceeding to shell it out from the surrounding adhesions.

In the average case the cæcum and appendix are easily brought out at the wound; the appendix is seized at its tip, to put the mesentery and the artery running along its free border on the stretch. The mesentery is elamped so as to secure the artery, or a rounded needle threaded with catgut is passed beneath the artery, so that when the ligature is tied there is no danger of its slipping. The mesentery is then divided (Fig. 171).

A smaller artery close to the base of the appendix may also require to be secured in the same manner. A crushing clamp is then applied to the base of the appendix, and when it is removed after a few seconds there is left only a thin tube of the serous coat, which is ligated with catgut (Fig. 172) and divided just beyond the ligature. To prevent leakage of the contents before cutting off the appendix, its proximal end is seized with artery forceps.

The ligated root of the appendix, after being touched with pure carbolic acid, is invaginated and buried by a purse-string or other suture of fine silk or celluloid thread. One or two points of Lembert suture may be inserted to make the sealing over still more secure. The meso-appendix is then inspected to see that all bleeding has

been arrested, and the cæcum is restored to its proper place. In the female, the uterus and its appendages should be examined before the abdomen is closed. The

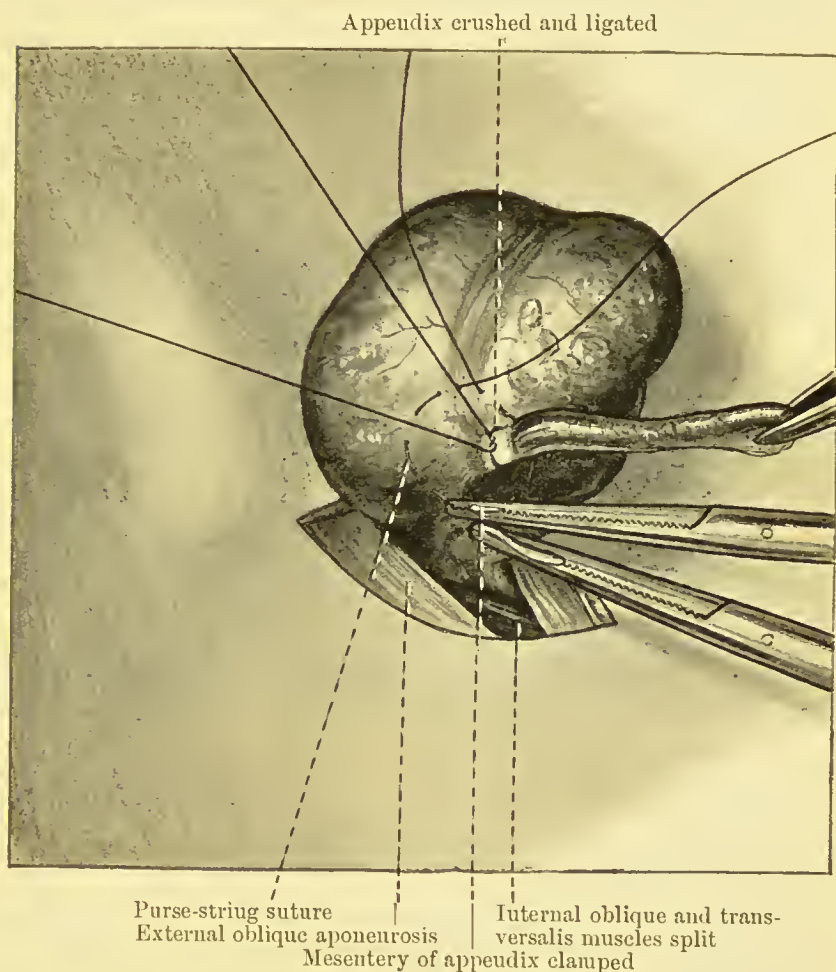


FIG. 172.—Removal of the Vermiform Appendix, 2nd stage.

wound is closed in tiers without drainage. A continuous suture of fine catgut should unite the edges of the superficial fascia, otherwise the scar is apt to broaden later.

**Removal of the Appendix during an Attack of Appendicitis.**—In operations performed within twenty-

four hours of the onset of the attack, the procedure is the same as in the interval operation. The incision through the sheath of the rectus is to be preferred, as it gives freer access. If there is an exudate, drainage may have to be provided for, a glass tube being pushed down to the bottom of the pouch of Douglas, where the exudate usually accumulates. The base of the appendix is secured by a catgut ligature and invaginated by a purse-string suture.

In operations performed from the second to the fifth day, preference should again be given to the incision through the sheath of the rectus. The operation must be as simple and short as possible, as the patient is usually the subject of general toxæmia or diffuse peritoneal infection. The appendix is identified and removed, and the stump buried in the usual way, but if the wall of the cæcum is friable, a catgut ligature passed round the base of the appendix may be sufficient. Suitable drains are inserted, one to the root of the appendix and one to the bottom of the pouch of Douglas.

In the female, if there is extensive pelvic peritonitis, a tube may be brought out through the posterior fornix of the vagina.

If there is great distension of the bowels, the recovery of the patient may be greatly promoted by one or more enterostomies performed by Witzel's method.

The abdominal wound is closed except where the tubes emerge, or the peritoneum and transversalis fascia are alone stitched, and the rest of the wound packed with moist gauze. In either case the wound is dressed with large hot compresses, frequently changed, to promote the escape of the peritoneal exudate. For the first few days the patient is kept in the Fowler position.

#### **The Operation for Abscess following Appendicitis.—**

The circumstances under which the operation is performed will to a large extent determine whether the



surgeon is to restrict himself to opening and draining the abscess and leaving the removal of the appendix to a later date, or whether he is at the same time to remove the appendix. In the latter case, the abdomen is opened to the mesial side of the abscess, the limits of which are determined, and the surrounding parts are

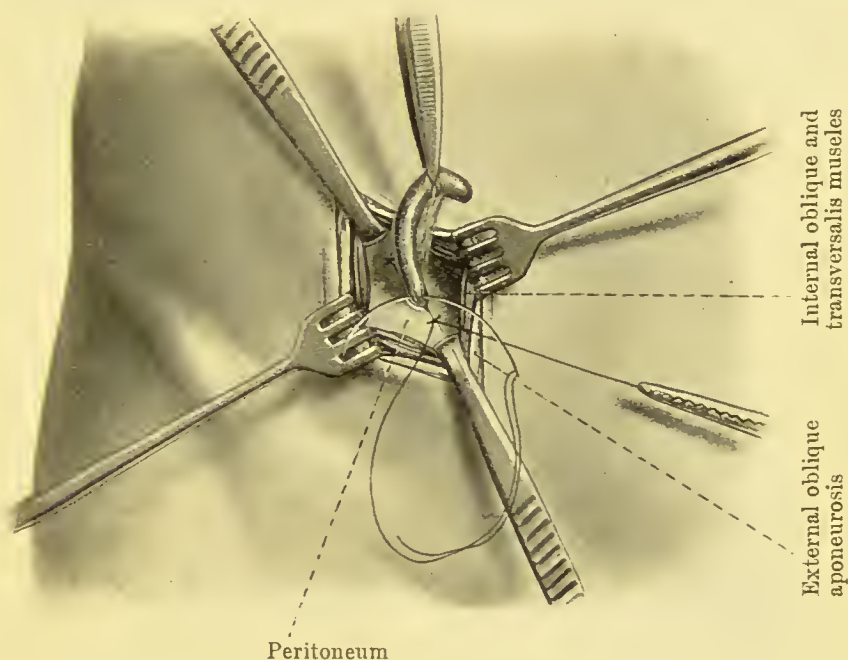


FIG. 173.—Appendicostomy, 1st stage.

packed off with gauze. The adhesions forming the wall of the abscess are gently separated until the pus appears, and this is mopped up as it escapes. Care is taken to remove any concretion that may have escaped from the appendix, and to change any packing that may have been soiled. The appendix is then traced from the cæcum and removed in the usual way. Drainage having been provided for, the rest of the wound is closed.

**Appendicostomy.**—The utilisation of the appendix for the purpose of irrigating the large bowel in cases of



colitis was first practised by Weir of New York. It may be employed for the same purpose in dysentery, and as part of the treatment for intestinal obstruction. The operation proceeds on the same lines as for removal of the appendix, and M'Burney's incision and gridiron method are usually preferred. The appendix is brought out at the wound until its root is on a level with the

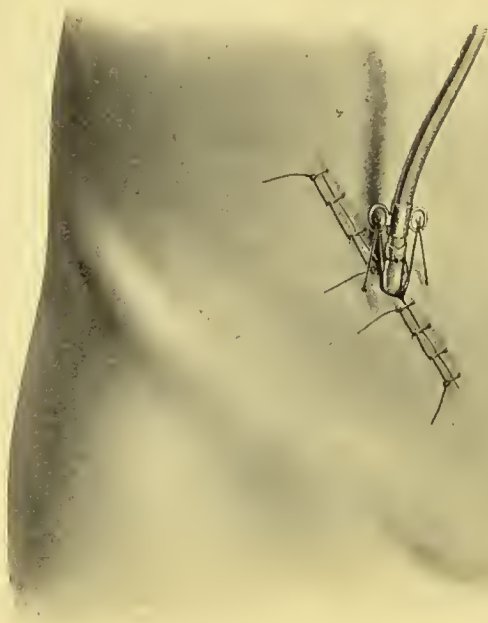


FIG. 174.—Appendicostomy, 2nd stage.

parietal peritoneum, to which it is anchored by a fine silk suture (Fig. 173). The tip is cut off and a probe is passed down into the cæcum to make sure that the lumen of the appendix is patent. A rubber catheter, about a No. 6 of the English scale, is passed and fixed in position, as shown in Fig. 174. It is usually necessary to wear the tube constantly, but when possible, it is only inserted night and morning when the irrigation is being carried out.

When the appendicostomy opening is no longer required, the root of the appendix is exposed by dissection, ligated with catgut, and cut away. We have usually done this under local anæsthesia.

If the appendix has previously been removed or is found to be unsuitable for irrigation purposes, a fistulous opening is made in the cæcum after the manner employed in Senn's gastrostomy (p. 412). This, however, is more likely to give trouble from occasional slight leakage of faecal matter.

## CHAPTER XXIX

### OPERATIONS ON THE STOMACH

TO EXPOSE THE STOMACH FOR PURPOSES OF EXPLORATION. GASTROTOMY. GASTROSTOMY. GASTRO-ENTEROSTOMY: *Posterior* (von Hacker); *the Roux operation by Y-method*; *Anterior*. PYLOROPLASTY. GASTROPLASTY. GASTRO-ANASTOMOSIS. GASTRO-DUODENOSTOMY. RESECTION OF THE STOMACH FOR CANCER: *Resection of Pyloric Portion by Billroth's second method*; *Resection by Kocher's method*; *Resection of Entire Stomach*. RESECTION OF THE STOMACH FOR ULCER.

**To expose the Stomach for Purposes of Exploration.**—To expose the stomach for purposes of exploration, the incision is made in or near the middle line above the umbilicus. When the peritoneal cavity is opened, the first viscus to appear is either the pyloric portion of stomach or the transverse colon with or without the great omentum. Above, there may be seen the lower edge of the left lobe of the liver. The view may be obscured to some extent by the falciform ligament of the liver, which sometimes contains a considerable amount of fat. The pyloric ring is identified as a slight annular constriction with a prominent vein running vertically under the serosa.

The pyloric portion of the stomach is drawn out at the wound and is inspected and palpated. It is drawn towards the right side to show up the lesser curvature, and then in the opposite direction to facilitate access to the duodenum. The hand is now passed up underneath the ribs and left lobe of the liver, to palpate the fundus

and cardia. The posterior wall of the stomach, which alone remains to be examined, is reached by way of the lesser peritoneal sac. The stomach and transverse colon are pulled out and turned upwards on the epigastrium, and the deep surface of the transverse meso-colon is exposed. To open into the lesser sac, a portion of the meso-colon devoid of large blood vessels is selected, and a vertical slit made in it (Fig. 177). Through this opening successive portions of the posterior wall can be brought out and examined, unless the lesser sac has been obliterated by adhesions.

When the exploration has been completed, the rent in the meso-colon is closed by catching the edges in forceps and tying ligatures round them.

**Gastrotomy.**—The object of this operation is to open the stomach for purposes of investigation or for the removal of a foreign body. The part of the stomach to be opened, usually the pyloric portion, is brought out at the wound and packed off with moist gauze. A fold of the anterior wall of the stomach midway between the curvatures is picked up with forceps and transfixed with a narrow-bladed knife; the edges of the opening are then seized with toothed forceps and the opening is enlarged with scissors to the desired extent, any vessels that bleed being secured as they are cut.

To remove a foreign body of limited size, such as a tooth-plate, or to dilate the pylorus, the opening is made at right angles to the long axis of the stomach, parallel with the larger blood vessels. For the removal of a large foreign body, for example, a hair ball, or of a body impacted in the lower end of the œsophagus or in the duodenum, to expose and secure a bleeding vessel, or to distinguish between a chronic ulcer and cancer, the opening must be much larger and should be made in the long axis of the stomach, dividing the larger blood vessels in the submucous coat.

When the object of the operation has been attained the opening is closed by the usual two tiers of sutures, the packs of gauze are removed, and the wound in the abdominal wall closed.

**Gastrostomy.**—This operation is performed when the gullet is obstructed, in order that nourishment may be introduced directly into the stomach. It is essential that the fistulous opening should be made valvular, so that neither food materials nor gastric secretion shall escape from it. Of the numerous methods recommended for making a valvular fistula, we have found those of Senn, and of Witzel as modified by Kader, the most generally satisfactory.

The first stage—that of *bringing the stomach out at the wound*—is the same in both. The incision is made vertically through the upper half of the left rectus. As the stomach is empty and contracted as a result of prolonged starvation, it does not as a rule present at the wound, and must be sought for beneath the left lobe of the liver. Generally the omentum first comes into view, and if it is pulled upon, the transverse colon and then the stomach can be brought within reach. The stomach is identified by its comparatively thick smooth wall, and by the distribution of the blood vessels proceeding from the greater curvature. If there is still doubt, the viscus may be traced with the fingers to the under surface of the diaphragm, and in doing this it is sometimes possible to feel the growth when it is situated at the lower end of the gullet.

The stomach is pulled out at the wound, and an area selected on the anterior wall in which the fistula is to be made, and the portion withdrawn packed off in the usual way. In the contracted state of the viscus, the opening will be on that portion which borders on the pyloric antrum.

In forming the fistula after the *method of Senn*, an



opening is made in the stomach just large enough to admit a rubber tube about the size of a No. 10 English

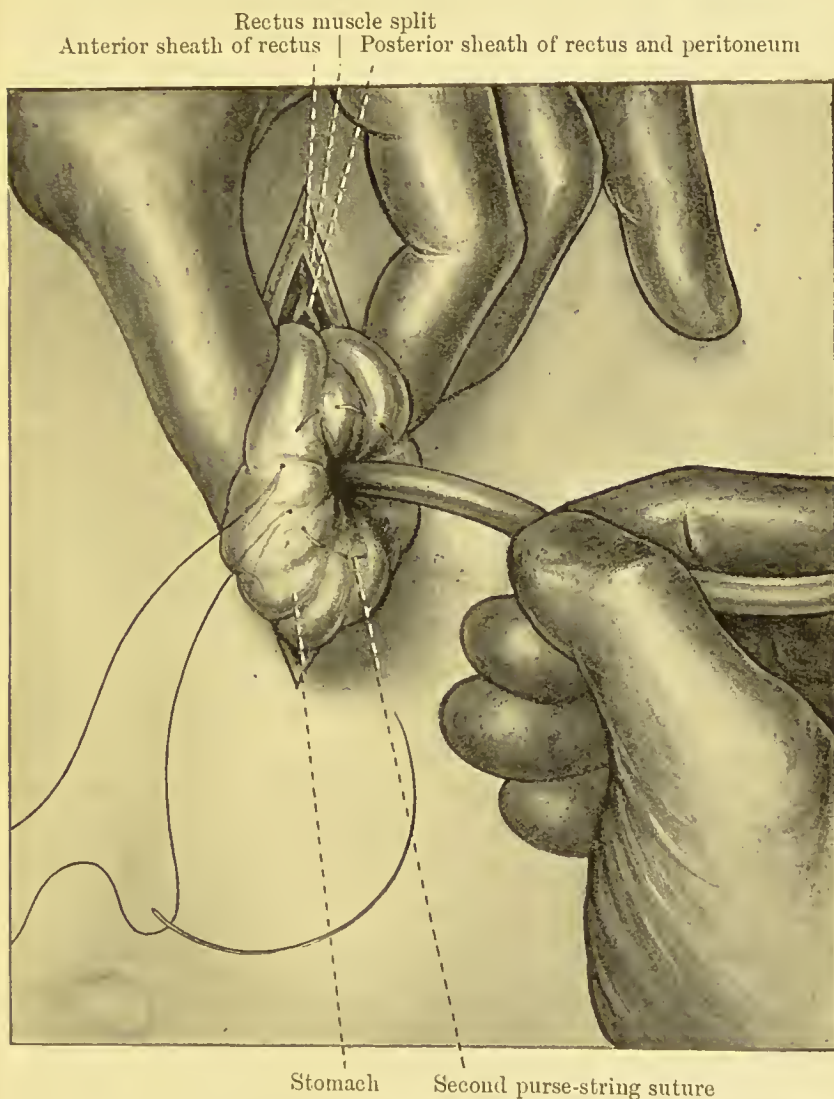


FIG. 175.—Gastrostomy by Senn's Method.

catheter; the tube is about two feet long and should have both a terminal and a lateral opening. The tube is pushed into the stomach for a couple of inches or so towards the pylorus, and secured to the edge of the open-

ing by means of a catgut stitch passed through its wall and through all the coats of the stomach. About half an inch away from the opening a purse-string suture is inserted, and while this is being tightened up and tied the opening and tube are invaginated into the interior of the stomach (Fig. 175). A second purse-string suture serves to invaginate them still further, and even a third may be used. The thread used for the last suture is carried through the edge of the parietal peritoneum and the sheath of the rectus in order to fix the stomach to the abdominal wall. To anchor the tube more securely, we employ a silver ring which grasps it tightly flush with the skin, and is provided with eyes through which tapes are passed, and these are tied round the body.

The free end of the tube is brought out through the dressing, and before the patient leaves the table, a quantity of warm milk, with white of egg, beef tea, and whisky is introduced into the stomach by means of a glass funnel. After the funnel is withdrawn the tube is plugged with a wooden spigot and secured to the dressing by means of a safety-pin.

In the *method of Witzel as modified by Kader*, a rubber tube is introduced into the stomach and secured by a catgut stitch as in Senn's operation, and then a vertical fold of the stomach is raised up on each side of the tube by a series of interrupted Lembert stitches, forming a tunnel two or three inches in length; a second fold may be taken up, and finally the stomach is anchored to the parietal peritoneum.

**Gastro-enterostomy.**—This operation, which consists in making an anastomosis between the stomach and the small intestine, was introduced by Wölfler with the object of providing a new outlet from the stomach when the pylorus is narrowed by scar tissue or blocked by a new growth. Its sphere of usefulness has been greatly

extended, and it is now widely employed as a therapeutic measure in chronic ulcer of the stomach or duodenum.

The jejunum may be anastomosed to the anterior wall of the stomach—*anterior gastro-enterostomy*,—or to the posterior wall—*posterior gastro-enterostomy*. The posterior operation is now almost universally preferred.

In planning the operation it is important to provide for a large opening not less than three or four inches in its long axis, to ensure that it will not undergo cicatricial contraction to such an extent as to lose its function as an outlet for the contents.

When the stomach is greatly dilated from pyloric stenosis, the maximum size of opening should be made, to allow for the contraction that will ensue as the stomach regains its normal dimensions.

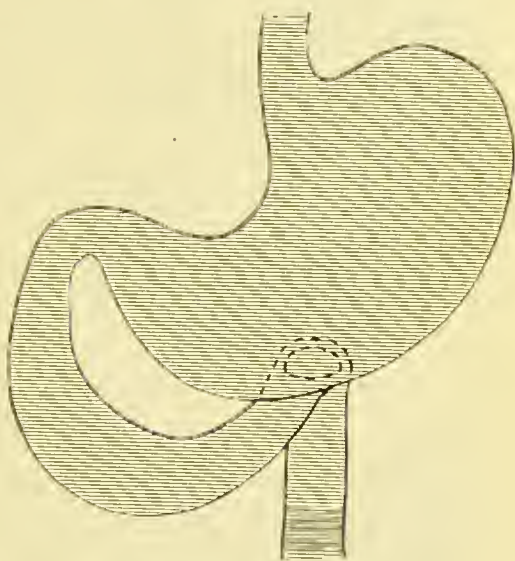


FIG. 176.—Diagram of Posterior Gastro-enterostomy.

Care must be taken also to arrange the loop of bowel employed in such a way that the contents of the stomach will not tend to enter the afferent loop and so pass back along the duodenum and through the pylorus into the stomach in a “vicious circle.” Improvements in technique effected by von Hacker, Mayo, Kocher, Moynihan and others have rendered the establishment of a vicious circle extremely rare.

*Posterior Gastro-enterostomy (von Hacker).*—The abdomen is opened in or near the middle line above the



FIG. 177.—Opening in Transverse Meso-colon made to expose posterior aspect of stomach.

umbilicus. Before proceeding to make the anastomosis, the whole stomach, the duodenum, the gall-bladder, the head of the pancreas, and the appendix should be



systematically examined, the whole hand being introduced into the abdomen for this purpose.

The omentum and transverse colon are then withdrawn and turned upwards over the epigastrium, and are held in this position by the assistant so that the meso-colon is rendered taut. At a bloodless spot within the arch of the mid-colic vessels, the meso-colon is caught with forceps, pulled away from the posterior wall of the stomach, and divided by a snip with the scissors alongside the forceps. The opening is then enlarged without damaging any of the blood vessels until free access is obtained to the lesser sac and to the posterior wall of the stomach, which is protruded through the opening by the fingers of the assistant. A sufficient amount of the stomach is pulled out through the opening, and in the further manipulations the beginner must remember that the great curvature is now directed upwards and the lesser downwards. The lowest part of the greater curvature, usually the antrum pylori, is selected for the anastomosis, and, to give better access to the most dependent portion, many surgeons follow Kocher in detaching the gastro-colic omentum from the stomach for a distance of about three inches, and dividing and tying the gastro-epiploic vessels.

The highest loop of the jejunum is then found by passing the fingers of the right hand backwards beneath the meso-colon, immediately to the left of the spine and just below the pancreas. Its identification is made certain by recognising that it is fixed at its upper end.

The highest part of the jejunum is brought into contact with the selected portion of stomach, and an anastomosis is made between them with or without the aid of clamps (p. 391).

The advantage of clamps is that bleeding and the escape of contents are prevented and the area of operation therefore remains clean. They have the drawback,



however, that it is impossible to introduce the fingers to explore the interior of the stomach, and when this is a matter of importance they should not be used, or the clamp on the stomach may be temporarily removed.

The opening in the jejunum is made in its long axis, and that in the stomach may also be made in the same direction. Certain advantages, however, accrue from making the incision in the stomach at right angles to the greater curvature. Mayo lays stress on the advantage of turning the loop of the jejunum employed in the anastomosis towards the left.

The anastomosis having been completed in the way described (p. 391), the edges of the opening in the meso-colon are brought over the junction and fixed to the jejunum with three or four points of suture to avoid the risk of coils of intestine making their way into the lesser sac and becoming strangulated (Moynihan).

The exposed viscera are now washed with saline solution, the packing removed, and the viscera returned to the abdominal cavity. It will usually be observed that the parts fall into their natural position, and that the anastomosed loop of jejunum leads directly downwards and so affords a ready escape for the contents of the stomach.

*Closure of the Pylorus.*—In atonic stomachs, in which the pylorus is quite patent, the results of a gastro-enterostomy are better if the pylorus is closed with a purse-string suture.

In the *Roux operation*—*gastro-enterostomy by the Y-method*—the jejunum is cut across about six inches from its origin, the open end of the distal segment implanted in the posterior aspect of the stomach by end-to-side anastomosis, and the open end of the proximal segment anastomosed end-to-side to the lower segment two or three inches from its junction with the stomach (Fig. 178).

The object of this procedure is to ensure that the gastric contents will pass into the distal loop of intestine and thus prevent a vicious circle. It is not to be employed in the treatment of gastric ulcer, because it prevents the alkaline intestinal secretions passing back into the stomach and neutralising the hyper-acid gastric contents, a factor which plays an important part in the healing of a chronic ulcer.

*Anterior Gastro-enterostomy.* —

The same incision is made as for the posterior operation. After the parts have been examined, the upper end of the jejunum is pulled out at the wound, and is traced downwards for eighteen or twenty inches. At this point the loop is brought in front of the omentum and transverse colon and anastomosed with the pyloric portion of the

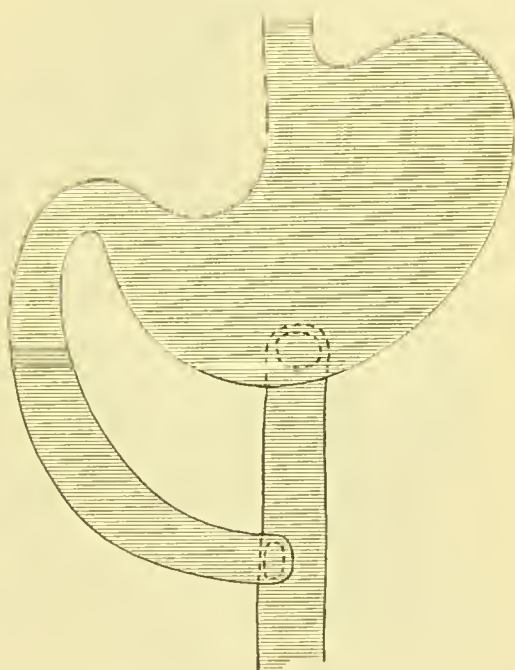


FIG. 178.—Diagram of gastro-enterostomy by the Y-method of Roux.

stomach. The anastomosis is described as iso-peristaltic, that is to say the direction of the peristalsis is the same in both viscera. To avoid obstructive kinking of the jejunum, the intestine should be united to the stomach by sutures over a greater extent than is required for the opening. To prevent the establishment of a vicious circle, Braun's plan of making an anastomosis—*entero-anastomosis*—between the two limbs of the loop of

jejunum united to the stomach should be followed; a small opening is sufficient, and it should be made about



FIG. 179.—Anterior Gastro-enterostomy with Entero-anastomosis (Braun).

two inches or so below the communication with the stomach (Fig. 179).

**Pyloroplasty.**—This operation was devised by Heinecke and Mikulicz for the purpose of widening a narrowed pylorus. A horizontal incision is made in the long axis of the gut, beginning in the anterior wall of the stomach

about an inch from the pylorus and passing for about an inch on to the duodenum; the edges of the wound are retracted upwards and downwards by means of hooks until the longitudinal wound is converted into a vertical one, and in this position it is closed with the usual two tiers of sutures. For additional security a convenient edge of omentum should be stitched over the line of suture.

The operation is rarely practised for cicatricial stenosis because of the objection to stitching scar tissue, but it is a useful method of closing the pylorus after it has been opened up by longitudinal incision for inspection of its mucous membrane or for the removal of an impacted foreign body, and in dealing with a perforated ulcer in the immediate vicinity of the pylorus. Under these conditions, by making the suture line at right angles to the long axis of the pylorus, the risk of subsequent contraction of the opening is diminished.

**Gastroplasty.**—This operation is performed to remedy an hour-glass contraction of the stomach, by widening the communication between the two pouches or compartments, and is carried out on the same principle as pyloroplasty.

**Gastro-anastomosis.**—This operation is also performed in hour-glass contraction of the stomach, and consists in making a lateral anastomosis between the most dependent parts of the two compartments. The steps are similar to those of gastro-enterostomy.

**Gastro-duodenostomy.**—This is an extension of the pyloroplasty of Mikulicz and Heinecke, and provides a very wide opening at the pylorus. In the treatment of gastric and duodenal ulcer we think that the ordinary gastro-enterostomy is to be preferred, as it causes an alteration in the chemical conditions of the stomach which is wanting in gastro-duodenostomy.

**Resection of the Stomach for Cancer.**—This operation



is intimately associated with the Viennese school of surgery, as it was first successfully performed by Billroth, and has subsequently been modified and improved by his pupils. Two of the methods of resecting the pyloric end of the stomach are associated with Billroth's name. His original or first method consists in removing the diseased segment and then uniting the cut end of the duodenum to the cut end of the stomach (Fig. 180). Owing to the disparity in size between the two divided

ends, and the difficulty of effecting a secure junction between them, this method is not often employed.

The second method (Billroth II.) consists, after resection, in closing both the stomach and the duodenum and restoring the continuity of the tract by means of a gastro-enterostomy (Fig. 182). Kocher's name is associated

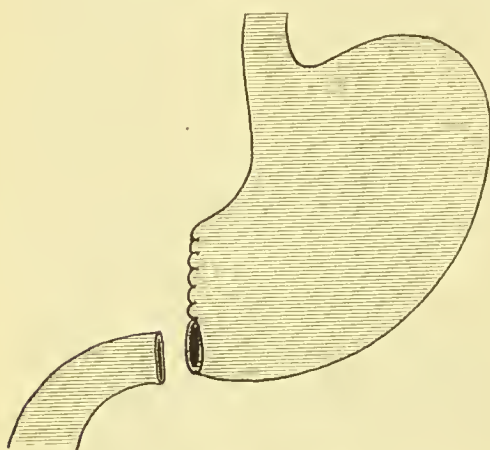


FIG. 180.—Diagram of Method of joining Duodenum to Stomach after resection of Pylorus by Billroth's first Method.

with a method in which the stomach is closed and the duodenum inserted into a fresh opening in the posterior wall of the stomach (Fig. 187).

*The Arteries concerned in Resection of the Stomach* (Fig. 181).—Along the greater curvature run the gastro-epiploic vessels, the left derived from the splenic, the right from the hepatic through the gastro-duodenal; the latter gives off also near the pylorus the superior pancreaticoduodenal, which always requires to be secured before or after cutting across the duodenum. At the lesser curvature are the coronary arteries; the right, often called the



pyloric, being derived from the hepatic, and the left from the celiac axis. All four arteries give numerous branches to the anterior and posterior walls of the viscus, and are accompanied by the corresponding veins, which ultimately open into the portal vein.

The *lymph vessels* that run towards the lesser curvature, and the glands into which they drain, are the

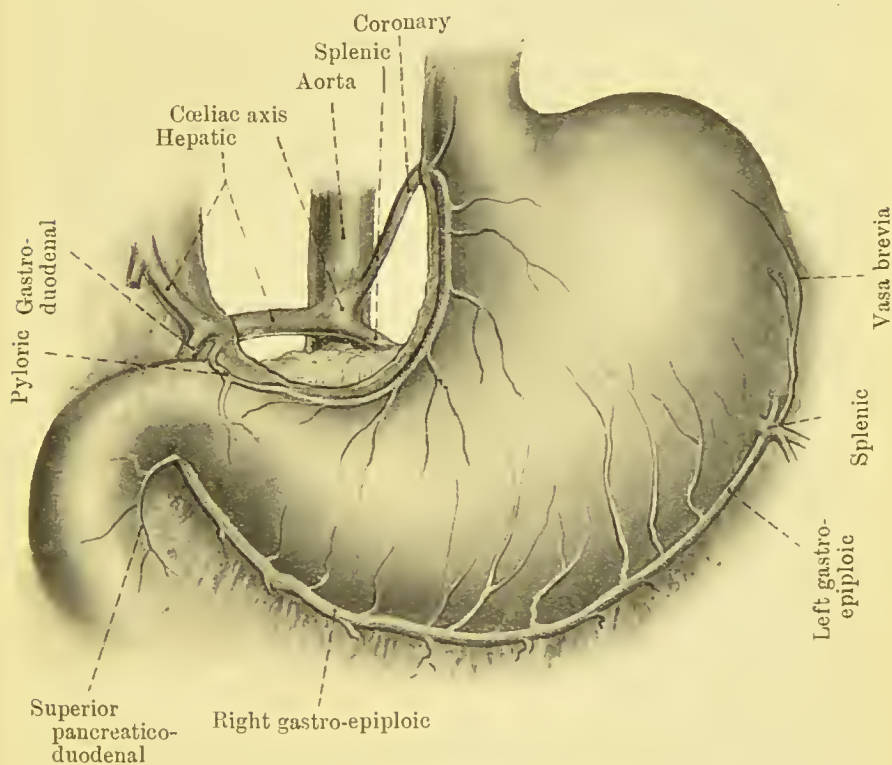


FIG. 181.—Blood Vessels of Stomach.

earliest infected, and it is important to remember that the extent of their infection is usually decidedly beyond the edge of the primary tumour. In order, therefore, to prevent local recurrence from this source it is necessary to resect the stomach and the lesser omentum containing these glands as far along the lesser curvature as the point of abutment of the coronary artery.

Infection of the lymphatics along the greater curvature occurs later, and is usually limited to the immediate vicinity of the pylorus.

**Resection of the Pyloric Portion of the Stomach by Billroth's Second Method.**—This operation is the one now most frequently practised. The abdomen is opened in or near the middle line, and the parts are explored to

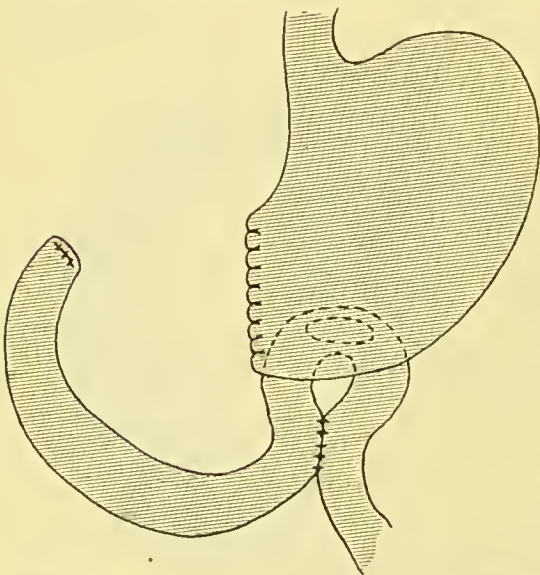


FIG. 182.—Diagram of condition obtaining after resection of Pylorus by Billroth's second Method, with Entero-anastomosis.

confirm the diagnosis and to determine the extent of the disease in the stomach itself, in the lymphatics, and in the neighbouring organs.

*Gastro - enterostomy.* — If it is deemed advisable to undertake resection, we have found it advantageous to establish the communication between the jejunum and the healthy portion of

the stomach before proceeding to the resection. If possible a posterior gastro-enterostomy is performed, and the intestine must be connected with the stomach as far as possible from the margin of the growth. There is not the same necessity as in other affections of the stomach that the opening should be at the most dependent portion nor that it should be a large one, as, being the only outlet when the resection is completed, it is sure to functionate. We have also found it advisable to make an entero-anastomosis between the

two limbs of the loop of jejunum employed for the junction with the stomach, as this prevents the accumulation of contents in the blind end of the duodenum and so diminishes the risk of leakage, which is the chief source of danger in this operation (Fig. 182).

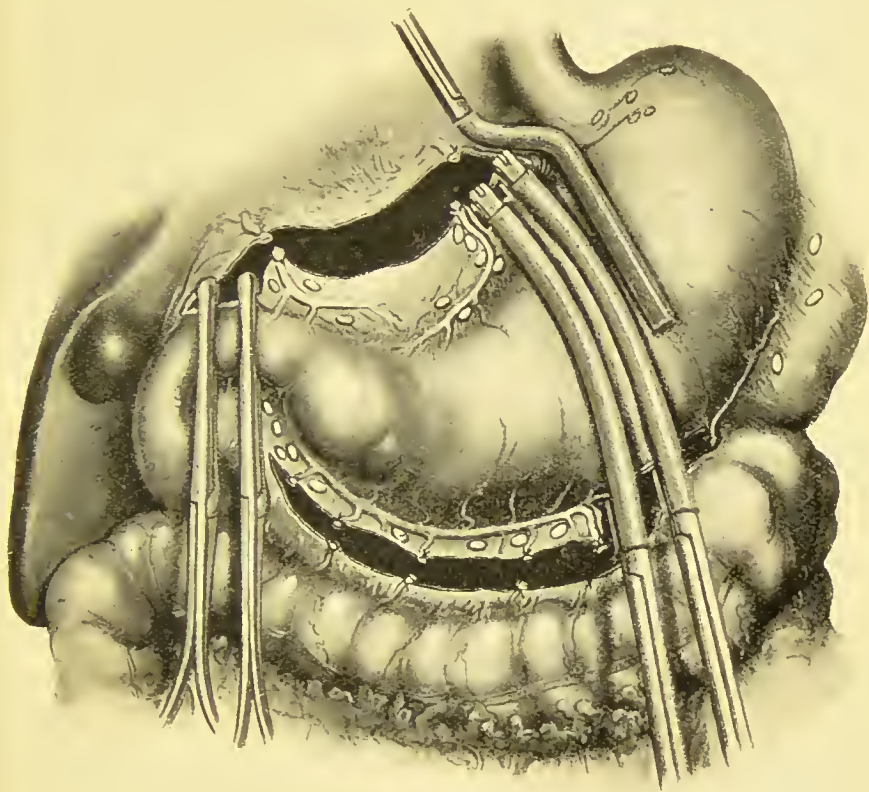


FIG. 183.—Resection of Pyloric Portion of Stomach, after Illustration by W. J. Mayo.

*Separation of Omenta.*—The second stage of the operation—the resection of the diseased segment of the stomach—is then proceeded with. The affected portion of stomach is drawn out at the wound and the surrounding parts packed off with gauze pads in the usual way. The lesser omentum is then separated from the stomach piece by piece between artery forceps or double ligatures,

keeping as far away from the stomach as possible, to be beyond the lymphatics that have been exposed to infection. On the right side, the separation proceeds as far as the middle of the first portion of the duodenum, and on the left as high as the abutment of the coronary artery.

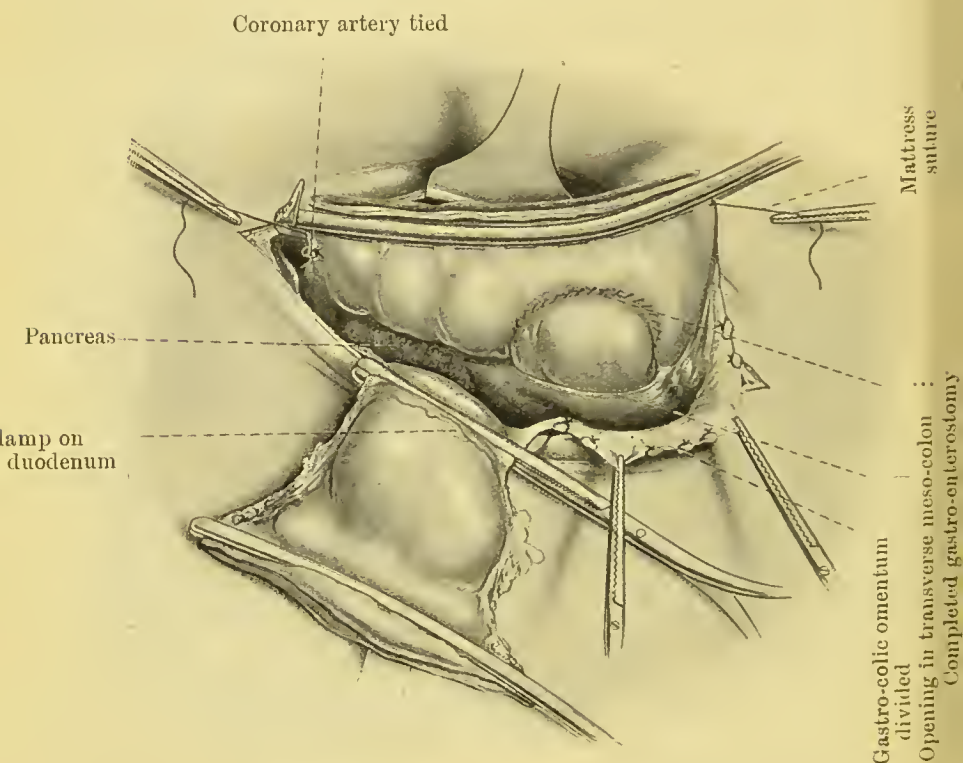


FIG. 184.—Resection of Pyloric Portion of Stomach by the Method Billroth II.  
(Looked at from right side of patient.)

The gastro-colic omentum is separated from the greater curvature in the same manner, but it is not necessary to keep so wide of the stomach as in separating the lesser omentum. The gastro-epiploic artery is divided between ligatures at the left end of the separated portion, and the pancreatico-duodenal at the right end.

It is important to deal with the omenta in this order,



as by separating the gastro-hepatic omentum first, there is less risk while dividing the gastro-colic omentum of wounding the middle colic artery, on which the nutrition of the transverse colon depends.

*Section and Closure of Stomach.*—The portion of stomach to be removed is now free from all its attachments, and gauze can be packed behind it. The line of section having been decided upon, a long powerful gastrectomy clamp, such as Kocher's, is applied fully one inch, if possible two inches, on the cardiac side of the palpable edge of the tumour, and nearer the pylorus a similar clamp is applied to prevent the escape of contents from the segment of stomach containing the growth. The stomach is then



FIG. 185.—Closure of Cardiac End of Stomach.

divided between the clamps, the exposed mucous membrane wiped with small gauze swabs on holders, and the distal end securely wrapped in moist gauze and folded towards the right side. To prevent the stomach slipping from the proximal clamp the cut edge should be seized in three or four places with catch forceps. A mattress suture is then inserted on the cardiac side of the clamp, and continuous through-and-through sutures at the cut edge (Fig. 185); as the latter is intended to obliterate the blood vessels, the stitches must be inserted close to one another and pulled tight.

The closed stump of the stomach is buried by a row of Lembert sutures; the invagination at the ends is made easier if each corner is grasped in non-toothed dissecting



forceps and pushed well into the interior of the stomach.

*Section and Closure of the Duodenum.*—As the carcinoma almost always stops abruptly at the pyloro-duodenal junction, it is usually sufficient to divide the gut

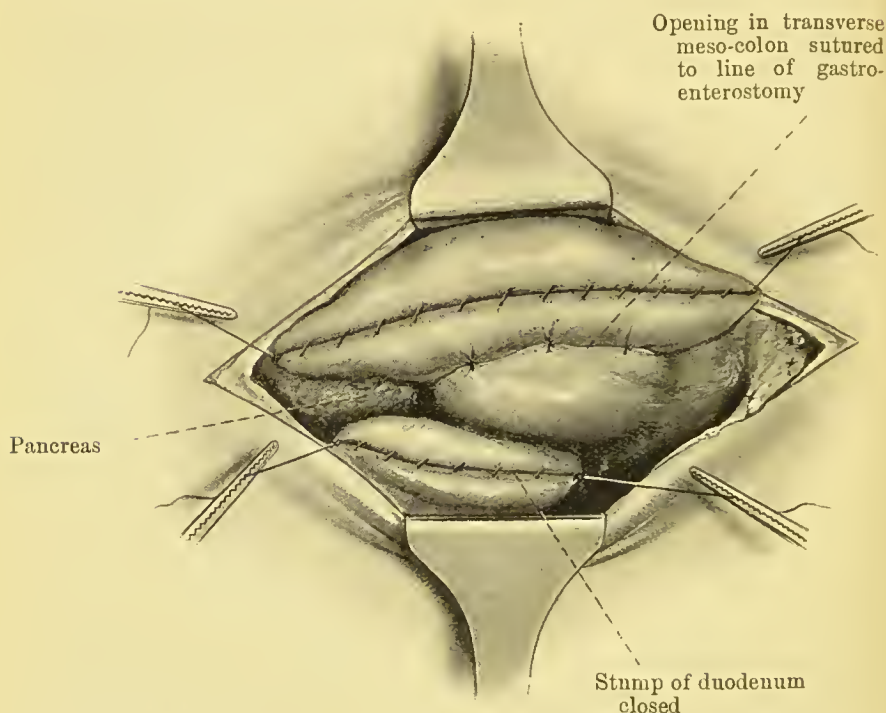


FIG. 186.—Resection of Pyloric Portion of Stomach by the Method Billroth II., completed.

(Looked at from right side of patient.)

one inch beyond this. Clamps are applied at the level decided upon and the duodenum is divided between them. The segment of stomach containing the growth being now completely separated is removed and laid aside. The cut end of the duodenum is closed by a continuous suture carried through all the coats, and the ends of the suture are tied together, the clamp controlling the stump being removed as the first knot is tied; and the stump, now

much reduced in size, is buried by one or more tiers of purse-string sutures. Finally, to give further support, the omentum or pancreas is stitched down to the stump.

After being purified the exposed parts are returned to the abdomen and the parietal wound closed.

**Resection of the Stomach by Kocher's Method.**—The resection of the cancerous segment of the stomach and the closure of the cardiac end are carried out on similar lines to those above described. The divided end of the duodenum, however, instead of being closed, is inserted into the posterior wall of the stomach about an inch to the left of its line of closure (Fig. 187). The junction is made by an end-to-side anastomosis by the ordinary two tiers of sutures, but if the portion of stomach remaining is limited the anastomosis may be carried out more easily with the aid of a Murphy button.

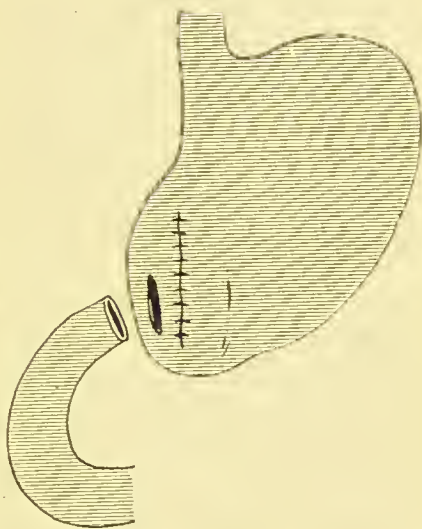


FIG. 187.—Diagram of Method of joining Duodenum to Stomach after Resection of Pylorus by Kocher's Method.

It must be conceded that the re-constituted alimentary passage departs less from physiological conditions in Kocher's method, but we believe that in inexperienced hands it is attended with a higher mortality because of the technical difficulties in anastomosing the duodenum to the stomach.

**Resection of the entire Stomach for Cancer.**—In exceptional cases the entire stomach may require to be removed. The operation is carried out on similar lines to those described for partial gastrectomy, and is com-

pleted by joining the lower end of the gullet to a loop of the upper portion of the jejunum. Schlatter and Moynihan have reported the cases of patients who survived the operation for several months.

**Resection of the Stomach for Ulcer.**—The resection of the affected portion of the stomach is planned on similar lines to that for cancer. There is often greater difficulty, however, because of adhesions to adjacent organs.

## CHAPTER XXX

### OPERATIONS ON THE INTESTINES

OPERATIONS ON SMALL INTESTINE: Jejunostomy; Enterotomy; Entero-anastomosis; Enterectomy.

OPERATIONS ON THE COLON: Mobilisation of the Colon; Resection of Ileo-cæcal Segment and Adjoining Colon; Resection of Colon beyond Hepatic Flexure; Resection of Pelvic Colon; Colostomy; Colopexy.

OPERATIONS ON SMALL INTESTINE. — **Jejunostomy.** — This operation is performed with the object of feeding the patient through an opening made in the highest part of the jejunum when the stomach is incapable of performing its functions; it is most often called for in cases of diffuse cancer of the stomach.

There are several methods of performing the operation, all of them designed, as in gastrostomy, to prevent leakage from the fistula. Mayo Robson's method, which is illustrated in Fig. 188, is both simple and efficient.

A vertical incision is made through the left rectus above the umbilicus, and the highest loop of jejunum is identified and brought out at the wound; a wide lateral anastomosis is made at the base of the loop between its two limbs, with the object of allowing the bile and pancreatic juice to pass on into the bowel beyond. At the convexity of the loop, an opening is made sufficient to admit a No. 10 rubber catheter, which is pushed for two or three inches into the efferent limb of the loop. The subsequent steps resemble those of a Senn's gastrostomy; the tube is anchored by a catgut

stitch, and the opening is then invaginated by one or more superimposed purse-string sutures. The coil of

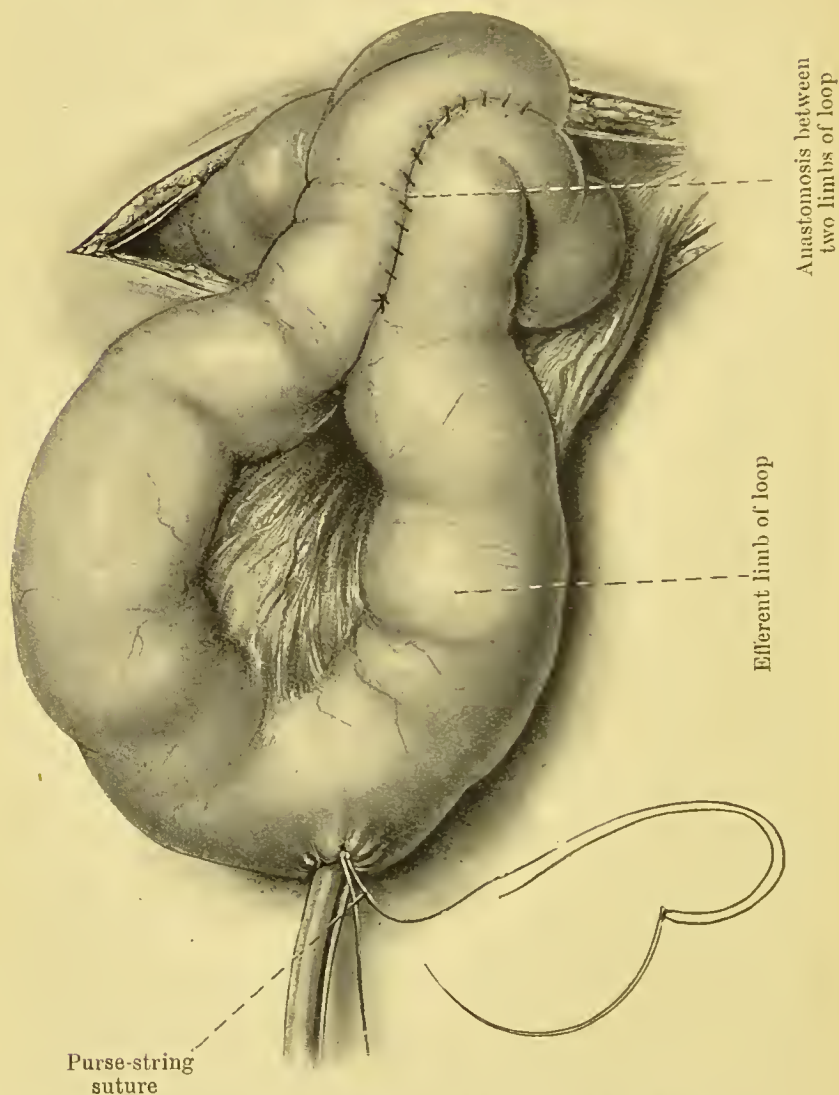


FIG. 188.—Jejunostomy by the Method of Mayo Robson.  
(Looked at from right side of patient.)

intestine is returned to the abdomen, and its apex secured to the parietal peritoneum and posterior sheath of the rectus; the parietes are then tightly stitched



round the tube. Feeding may be commenced at once.

**Enterotomy.**—This procedure consists in opening the small intestine to remove an obstructing body such as a gall-stone, or to empty the bowel of its contents in the course of an operation for intestinal obstruction.

The loop of bowel concerned is brought out at the wound, and after being seized at its root with a suitable

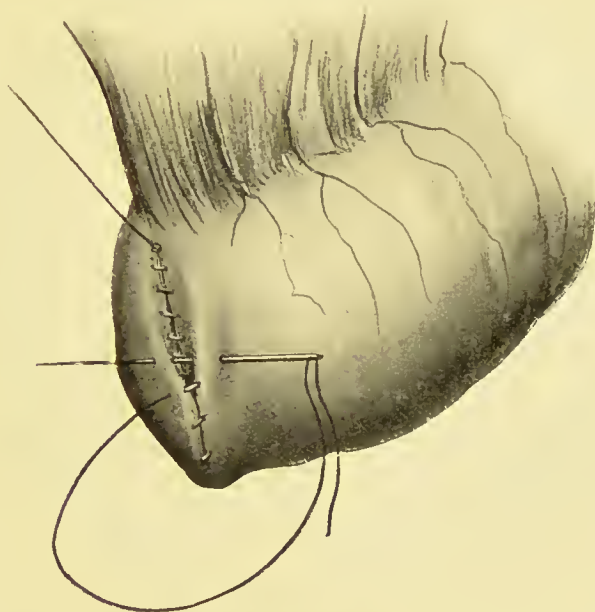


FIG. 189.—Closure of the Divided Small Intestine by two tiers of Suture.

clamp, is opened by a transverse incision on the side opposite the mesentery and the foreign body removed. The clamp is then relaxed to permit of the escape of the contents, and is reapplied while the opening is being closed with the usual double tier of sutures. Finally the intestine is cleansed and replaced in the abdomen, and the parietal wound closed.

In a case of obstruction, a double-flanged glass tube of the Paul variety is tied in by a purse-string suture

carried through all the coats, and connected with a tube of thin rubber to carry away the contents to a receptacle placed alongside the bed.

**Enterostomy.**—This term is employed when the opening in the small intestine is to be retained for some time, usually to drain the bowel in cases of intestinal obstruction. It is a simple operation, and may be done under local anæsthesia.

The initial steps are the same as in enterotomy; the bowel is drawn out, clamped, and a Paul's tube is tied in.

The portion of gut to which the tube is attached is then stitched to the parietal peritoneum and fascia with two or more sero-muscular stitches. When the clamp is removed, it may be some minutes before the return of peristalsis expels any of the contents.

The stitch holding the Paul's tube cuts through in a few days and the tube becomes loose; but by this time adhesions have formed, which protect the peritoneal cavity, while the wound surfaces are protected as a result of the ordinary changes in repair.

If the drainage of the bowel is only wanted for a day or two, a rubber tube may be inserted into the intestine by an oblique fistula made by Senn's or Witzel's method; this method has the advantage that when the tube is removed the fistula usually closes spontaneously.

**Entero-anastomosis.**—The different methods of performing entero-anastomosis, or short-circuiting of the bowel, have already been described (p. 391).

**Resection of the Small Intestine.**—**Enterectomy.**—The segment of bowel to be resected is brought out at the wound, its contents expressed by the fingers in both directions, and a suitable clamp, or preferably a pair of clamps (Fig. 190), applied above and below. It is essential that these should be applied well beyond the limits of the disease in order to make certain of having healthy intestine to suture. The mesentery is divided

bit by bit, also well beyond the disease; this is conveniently done between two artery forceps, with subsequent ligation of the portions of tissue included in their grasp. The intestine is cut across at either end with straight scissors, as close as possible to the limits

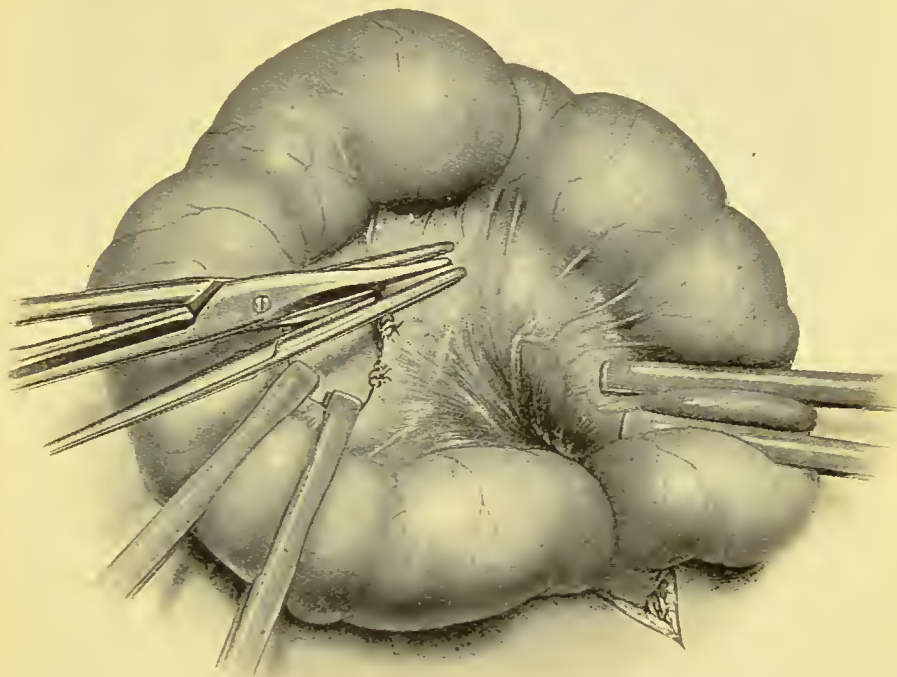


FIG. 190.—Resection of the Small Intestine. The Bowel is clamped and the Mesentery is being divided.

of separation of the mesentery. The section is not made at right angles to the long axis, but obliquely, so that more of the free border is removed than of the mesenteric. This oblique section of the bowel ensures a better blood supply to the cut edges, and diminishes the risk of narrowing the lumen of the gut when the ends are united by circular suture.

The ends are now approximated, and are united end

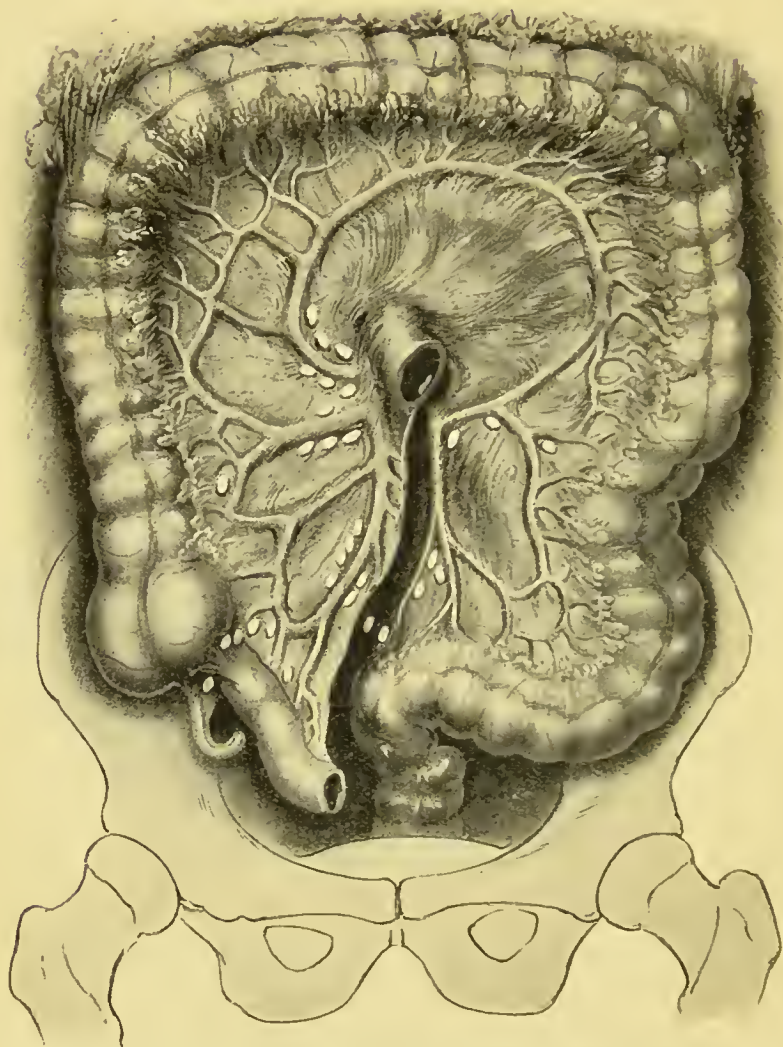


FIG. 191.—The Blood Vessels and Lymph Glands of the Colon.

to end by the usual double tier of sutures, or in emergency with a Murphy button. The adjaeent omentum may be sutured over the junction; and the gap in the mesentery is closed with sutures. The elamps are removed, the bowel eleansed and returned to the abdomen, and the parietal wound closed.



If the security of the end-to-end junction is uncertain, especially if the lumen of the bowel above, from having been distended as a result of chronic obstruction, is much greater than that of the bowel below, it may be better to close both ends (Fig. 194) and make a lateral anastomosis between them.

**OPERATIONS ON THE COLON.**—From the operative point of view the colon differs markedly from the small intestine. The mesentery of the ascending and descending portions is so short and broad that it requires to be divided and the gut thus mobilised so that it may be brought outside the wound. The conditions for healing after suture also are less favourable, and the contents are much more infective. One of the great dangers in operations on the colon is that the sutures are liable to cut through even at a late stage in the healing process, and admit of leakage occurring.

**Mobilisation of the Colon.**—The practice of mobilising the fixed parts of the colon has rendered possible a great advance in the surgery of the large intestine. The fixed parts are the ascending and descending portions, the hepatic and splenic flexures, and the iliac colon. To render these parts mobile, the outer layer of the meso-colon—that is, the layer farther away from the umbilicus—is divided parallel with the colon, and by means of the fingers the colon is stripped from the posterior abdominal wall sufficiently freely to admit of its being brought out at the wound. It is still attached by the inner layer of the meso-colon and by the blood vessels. In this process of mobilisation care must be taken of the duodenum on the right side, and of the ureter and vas deferens on both sides.

*The Lymphatics of the Colon* have been made the subject of special study by Jamieson and Dobson of Leeds. Groups of lymph glands are found in relation to the different sets of blood vessels, and in order to



remove those that are liable to be infected, it is necessary to resect the mesentery in which they lie close up to the point at which the corresponding artery arises from the superior mesenteric; and in the case of the inferior mesenteric, which supplies the pelvic colon, up to its origin from the aorta.

**Resection of the Ileo-cæcal Segment and Adjoining Colon.**—This operation is usually performed for malignant disease originating in the cæcum or in the ascending colon. W. J. Mayo has pointed out that it is advisable to include the ascending colon with the cæcum, because many cancers originating at the ileo-cæcal valve extend upwards into the colon as well as downwards into the cæcum, and also because both the ileo-colic and right colic groups of glands are liable to be infected.

The incision is made over the tumour in the line of the fibres of the external oblique, and, if the disease is not too far advanced, the muscles are separated widely by the gridiron method. When the peritoneal cavity has been opened, an investigation is made of the extent of the disease, and particularly of the relations of the tumour to the parietes, and of the condition of the lymph glands in the associated mesentery. The close resemblance which tuberculous disease of the cæcum may bear to cancer is to be kept in mind; when there is any doubt, one of the enlarged glands in the mesentery should be removed for immediate examination.

If a radical operation is decided upon, any adherent omentum is divided and ligated piecemeal, and the omentum and small intestine are displaced to the left and packed off. The outer layer of the ascending meso-colon is divided, and the colon and fat are stripped cleanly towards the middle line from the muscles of the posterior abdominal wall (Fig. 192). The stripping is continued nearly as far as the origin of the ileo-colic and right

colic arteries from the superior mesenteric; the ligation of these arteries about one inch from their origin greatly facilitates the further steps of the operation.

The mesentery of the lower six or eight inches of the ileum is divided and ligated piecemeal, thereby securing

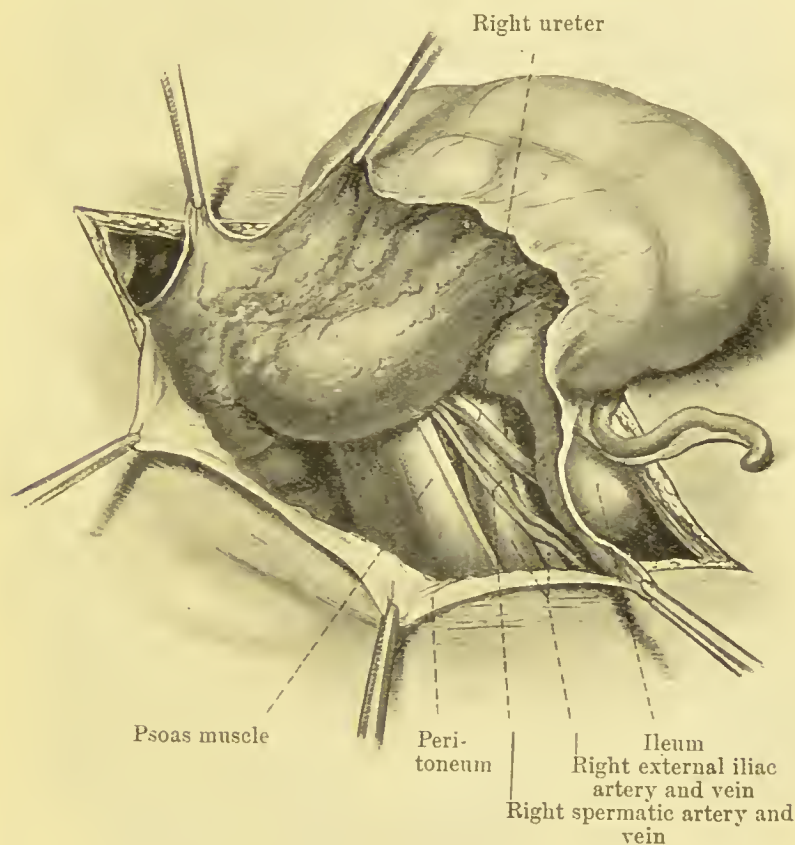


FIG. 192.—Mobilisation of the Cæcum and Ascending Colon.

a portion of ileum that will be sufficiently movable to be afterwards joined to any part of the colon.

The cæcum, ascending colon, and lower ileum are brought out at the wound, and the peritoneal cavity is packed off with gauze. The ileum is doubly clamped and divided, and the colon is similarly dealt with; the

inner layer of the meso-colon is divided on the proximal side of any enlarged glands, and the diseased segment of bowel laid aside.

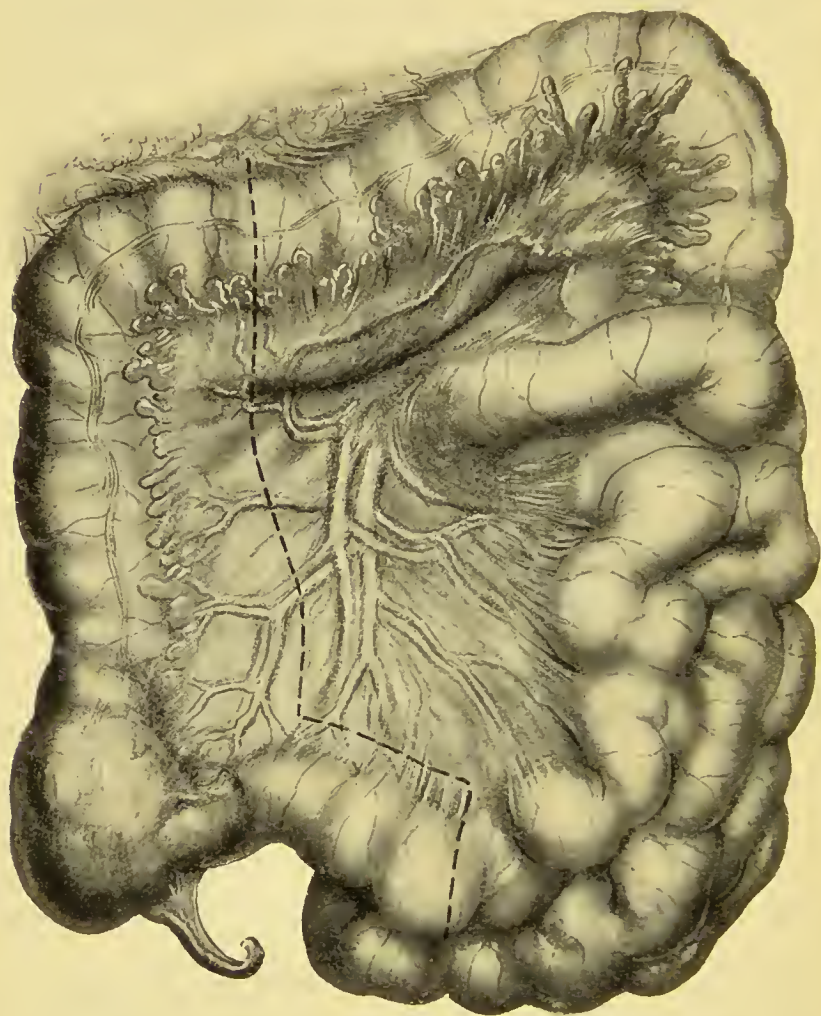


FIG. 193.—Extent of Resection in Cancer of Ileo-caecal Segment of Intestine.

“As looked at from the purely technical standpoint, a carcinoma existing at any point between the ileo-caecal orifice and the junction of the right with the middle third of the transverse colon, can be most safely treated

by complete removal of all the large bowel up to that point, and this also most effectually removes the lymphatics that are likely to be infected " (W. J. Mayo).

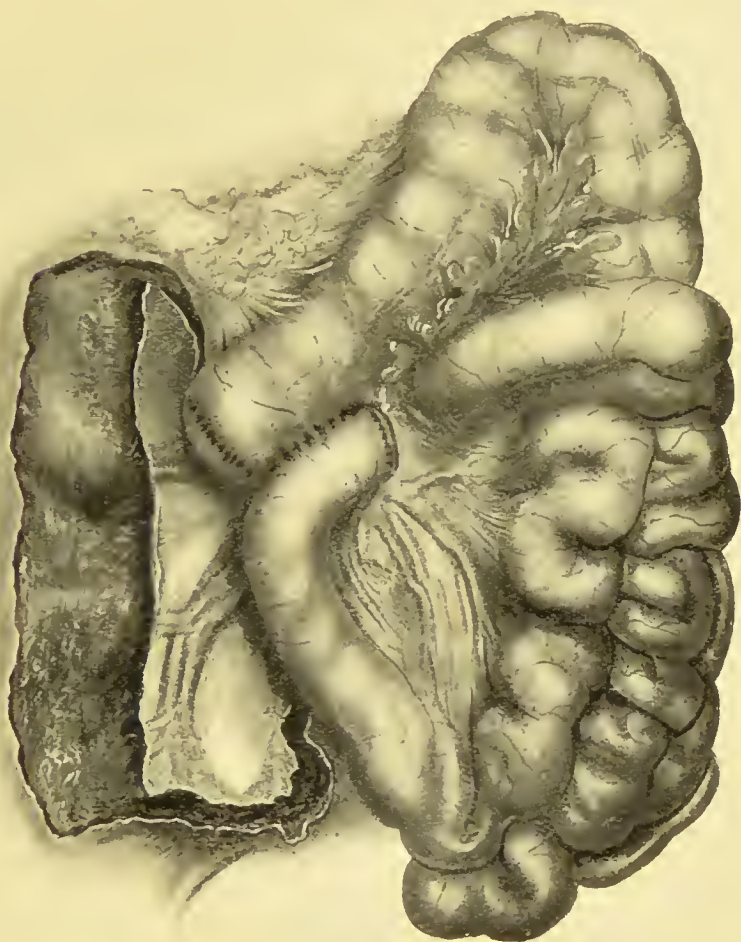


FIG. 194.—Lateral Anastomosis between Ileum and Transverse Colon after Resection of Cæcum and Ascending Colon for Cancer.

The cut end of the ileum must now be joined to the cut end of the colon; when the two portions of gut are nearly equal in size, an end-to-end junction may be made; as a rule, however, it is better to close the colon and insert the ileum into it end-to-side (Fig. 194), or



both ileum and colon are closed and the communication re-established by lateral anastomosis (Fig. 194). If for any reason any of these junctions is impracticable, the ileum may be inserted into the pelvic colon (Fig. 167).

Before the abdomen is closed it is necessary to cover over the area on the posterior abdominal wall that has been deprived of its peritoneum. It may be necessary to mobilise the parietal peritoneum in order that it may be stitched to the divided meso-colon. It is recommended that drainage should be provided for.

In early cases of localised cancer in the cæcum or ascending colon it may not be necessary to perform the above extensive operation; we have obtained a number of radical cures by a localised resection of the gut.

#### **Resection of the Colon beyond the Hepatic Flexure.—**

In resections involving the middle of the transverse colon, the middle colic artery, derived from the superior mesenteric, should be ligated at an early stage, and from the point of ligation, separation of the meso-colon with its glands is proceeded with.

In the case of *the splenic flexure*, the costo-colic ligament and the outer layer of the meso-colon are divided, thus liberating the colon, which along with the fat and glands can be drawn out of the abdomen. The left colic artery is ligated and divided. In the *descending and iliac portions of the colon*, and in the *greater part of the pelvic colon*, the steps of the operation correspond very closely to those described for the cæcum and ascending colon.

**Resection of the Pelvic Colon**, with complete removal of the lymphatic tributaries, may necessitate ligation of the inferior mesenteric artery close to its origin from the aorta (Fig. 195) in order to ensure removal of the glands that are liable to be infected.

The incision is made in the line of the fibres of the



external oblique, and the deeper muscles are split in the direction of their fibres. The extent of the disease is investigated; if the conditions are unfavourable for a

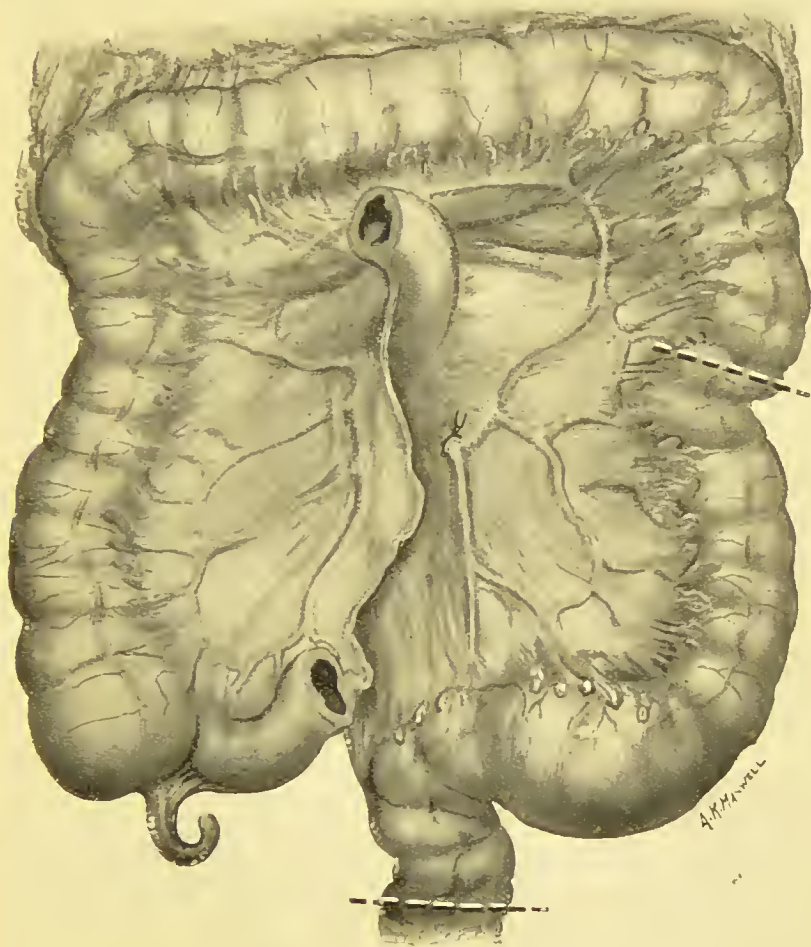


FIG. 195.—Extent of Resection recommended in Cancer of Pelvic Colon.

radical operation, an anastomosis is made between the lower end of the ileum and the colon beyond the growth. If, on the other hand, the conditions permit of a radical operation, it is carried out somewhat on the following lines.

The tumour is separated from any adherent omentum,

and is pulled out along with such loops of small intestine as may be adherent to it; the surrounding parts are then packed off with gauze. The outer layer of the meso-colon is divided, and the tissues of the mesentery stripped towards the centre of the abdomen until the bowel is sufficiently freed to be brought outside. The meso-colon with its inner lining of peritoneum is tied off in pieces with stout catgut. The extent of resection and the means of restoring the continuity of the bowel are now decided upon. The ideal method is to cut across the bowel between clamps well above and below the tumour, and to unite the cut ends directly by circular suture, or, after closing both ends, to make a lateral anastomosis between them. In the latter case the junction should be iso-peristaltic, and the anastomotic opening should be as close to the ends as possible, so as not to leave any pouch beyond. If it is found that there is likely to be tension after bringing the ends together, the adjacent colon must be mobilised.

The stitching must be very accurate, and special care is taken to ensure perfect serous apposition at the point where the meso-colon joins the gut. The clamps are removed, the bowel is cleansed and returned, and, drainage having been provided for, the abdominal wound is closed. W. J. Mayo advises that if leakage is feared, the anastomosed loop should be stitched to the peritoneum just beneath the wound and strips of rubber tissue carried down to it so that any leakage may readily find its way to the surface.

The junction of the divided colon may also be effected by invaginating the proximal into the distal end as shown in Figs. 196, 197, 198.

If the conditions are unfavourable for operation, and especially if the bowels are loaded, it is much safer to carry out the *resection of the colon by the three-stage operation of Mikulicz and Paul*. The first stage consists in

opening the abdomen and pulling the segment of colon containing the tumour along with its mesentery and glands out at the wound. The protruded colon forms a

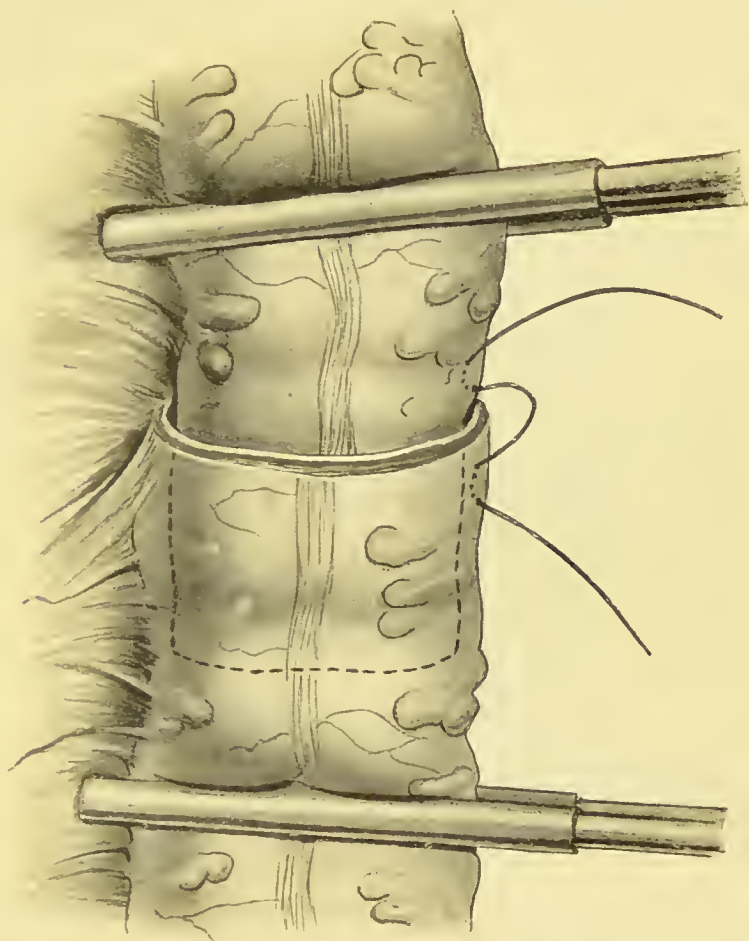


FIG. 196.—Junction of Colon by Invagination Method—A.

loop of which the two limbs are now united by a sero-muscular suture, and are also fixed by a few interrupted sutures to the parietal peritoneum. A Paul's tube is inserted into the proximal loop, and a rubber tube attached to it after the manner described in enterostomy. The parietes are brought together above and below the

protruded bowel, and a dressing is applied which will not adhere to the gut; a sheet of dental rubber or gauze thickly spread with vaseline will serve this purpose. From the third to the fifth day, the protruded bowel which is the seat of the tumour is cut away with the

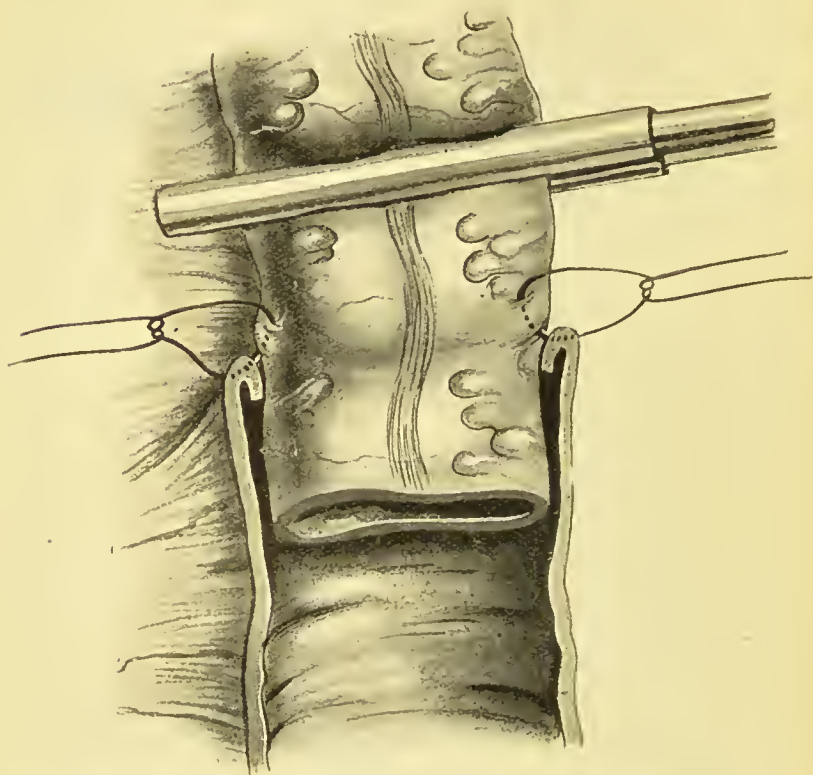


FIG. 197.—Junction of Colon by Invagination Method—B.

actual cautery, almost flush with the skin, and a Paul's tube is tied into each open end by means of a purse-string suture.

The tubes become loose in from four to seven days, and the opening acquires the characters of an ordinary artificial anus. At the end of from twelve to eighteen days from the first stage of the operation, the spur or septum between the two portions of gut is got rid of,



usually by a crushing clamp or enterotome, the instrument being left in position until the tissue included in its grasp undergoes necrosis and comes away. There is a considerable tendency for the fistula to close of

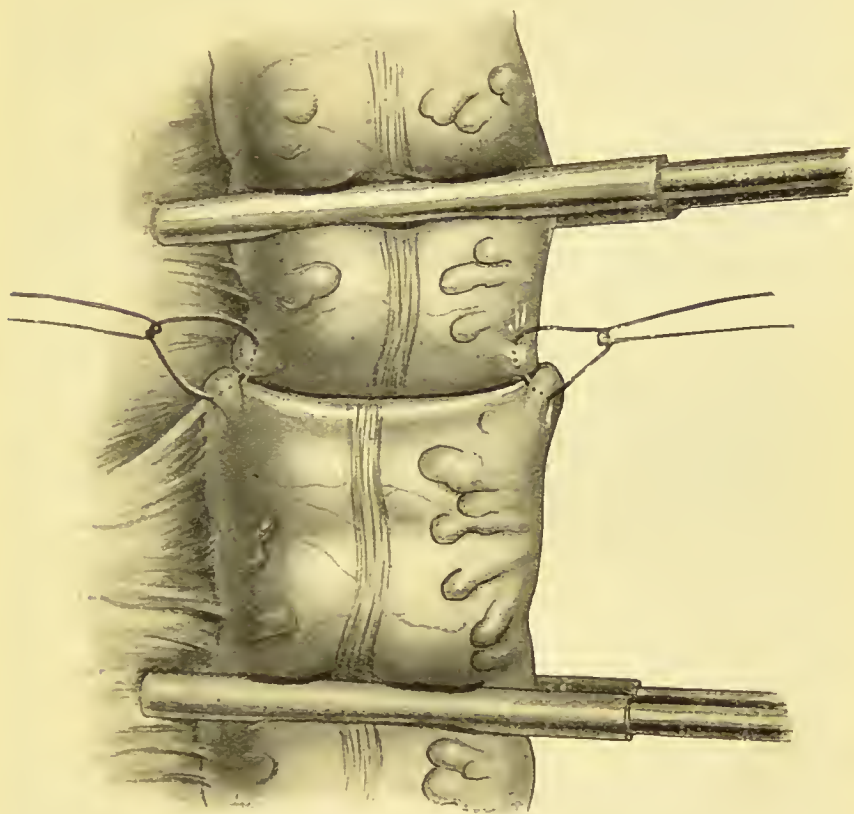


FIG. 198.—Junction of Colon by Invagination Method—C.

itself, but further dissection and stitching may be required to bring this about. This operation in stages is attended with a lower mortality. Its disadvantages, however, are considerable; the patient is subjected to a longer convalescence, to the discharge of fæces at the wound, and, finally, it does not permit of the dissection necessary for the removal of the associated lymphatics.



**Tumours in the Lower Part of the Pelvic Colon** are the most difficult of all to remove by operation. They are best dealt with by a combined abdomino-perineal method, which will be described in relation to cancer of the rectum (p. 472).

**Colostomy.**—This operation consists in making a permanent opening in the pelvic colon, and is chiefly performed to afford relief in cases of inoperable cancer of the rectum.

If the obstructive symptoms predominate and call for immediate emptying of the bowel, the operation is completed at one sitting, but if the obstruction is not acute, it is of great advantage to perform the operation in two stages. The first consists in bringing out a loop of colon and fixing it until adhesions have formed between the visceral and parietal peritoneum, and shut off the peritoneal cavity; the second, in opening the bowel.

The abdomen is opened on the left side by M'Burney's gridiron method, in the same way as is done for removal of the appendix on the opposite side. The pelvic colon may present at the wound or may have to be searched for by running the fingers of the left hand across the iliac fossa until the meso-sigmoid is reached, when a loop is drawn up to the surface and brought out at the wound.

Some surgeons lay stress on the necessity of pulling out the highest part of the pelvic colon to prevent prolapse of the bowel. We have given up this practice, as the patient is deprived of the use of the pelvic colon as a faecal reservoir, and we have not had any trouble from prolapse.

There are various methods of securing the loop in position. A simple plan is to choose a bloodless area in the mesentery, transfix it with a pair of forceps, and draw back through the hole thus made a roll of gauze (Fig. 199), a glass rod, or a large piece of rubber tubing;

or to fix the mesentery to the parietes by one or more mattress sutures. If the operation is to be completed at one sitting, a large Paul's tube is introduced in the usual way, as shown in Fig. 199.

If the bowel is not to be opened at once, a square of dental rubber, or gauze thickly spread with vaseline is applied over it to prevent the dressings adhering.

In the absence of obstruction, two or three days are

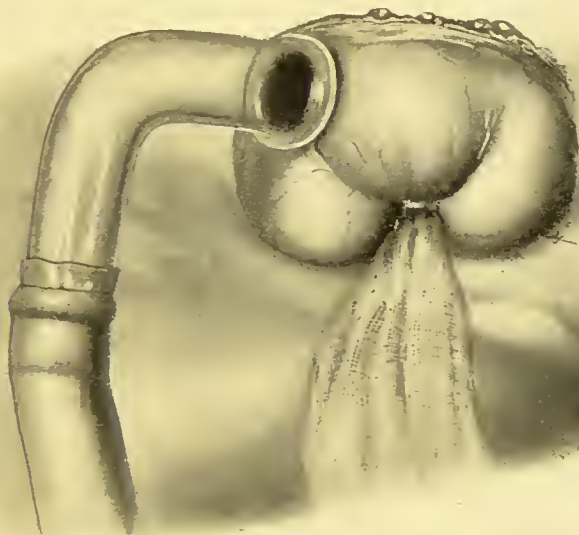


FIG. 199.—Colostomy in the presence of Obstruction. A Paul's Tube is tied in the Bowel.

allowed to elapse, but in exceptional cases we have deferred the opening for a week or ten days, without detriment to the patient. The opening is made with the Paquelin cautery either across the line of the gut, as we prefer, or in its long axis. Rutherford Morison has found that a good deal of blood may be lost from the cut edges of the bowel some hours after it has been opened, and to prevent this, he recommends that a piece of rubber tubing should be tied tightly round the bowel and allowed to ulcerate its way out. In this way the bowel is divided right across and there is no bleeding.

Instead of simply opening the bowel, it may be cut completely across with the knife or cautery, and a Paul's tube inserted into each segment (F. M. Caird).

In performing colostomy, Mr. Paul does not now use the tube called by his name or any other appliance. He makes the colon project in the form of a cone a little above the skin level, and stitches the base of the cone to the parietal peritoneum.

Another modification of the operation consists in bringing out a loop of the pelvic colon, and after cutting it across, ligating and invaginating the lower end, and then returning it to the abdomen. The upper end is brought out at the wound with a Paul's tube secured in its cut extremity. This operation tries the endurance of a weakly patient unduly, and if the operator makes any mistake as to which is the upper and which the lower end of the loop the result is disastrous.

**Colopexy.**—This operation is designed to tighten up and anchor the lower part of the pelvic colon in the treatment of prolapse of the rectum.

Lenormant, Quénu, and Duval have contributed to the following method of performing the operation. The patient is placed in the high Trendelenburg position, and the abdomen is opened in the middle line between the umbilicus and the pubes. In the female, the uterus is drawn upwards and forwards with forceps, and the prolapse of the rectum is fully reduced by making traction on the pelvic colon. The pouch of Douglas is now obliterated by two or more tiers of purse-string sutures. The lowest part of the pelvic colon is sutured to the pelvic peritoneum so that it lies horizontally from right to left. The lowest portion is fixed by interrupted sutures to the right broad ligament, and a series of eight to ten interrupted sutures fix the bowel to the back of the vagina and to the left side of the true pelvis up to the brim. An incision is now made in the iliac fossa

outside the iliac vessels, exposing the iliac fascia and the tendon of the lesser psoas muscle; fine sutures are passed through the peritoneal coat of the pelvic colon, through the right side of the peritoneal incision, and through the iliac fascia and tendon of the lesser psoas muscle; these sutures, when closed securely, fix the pelvic colon; the left free edge of divided peritoneum is then stitched to the colon. In the male, a similar operation is recommended: the recto-vesical pouch of peritoneum is closed by sutures in the same way as the pouch of Douglas is obliterated in the female, the free border of the colon is stitched to the back of the bladder horizontally from right to left, and the pelvic colon is fixed to the iliac fossa.

## CHAPTER XXXI

### OPERATIONS FOR HERNIA

GENERAL. HERNIOTOMY FOR INGUINAL HERNIA: *Methods of dealing with Sac; Methods of dealing with Canal; Operation for Large Irreducible Hernia; Hernio-laparotomy; Operation for Strangulated Inguinal Hernia.* HERNIOTOMY FOR FEMORAL HERNIA. *Method of dealing with Sac; Method of dealing with Canal; Operation for Strangulated Femoral Hernia.* OPERATIVE CURE OF UMBILICAL HERNIA. OPERATIVE CURE OF VENTRAL HERNIA.

THE operative treatment of hernia has been greatly simplified within recent years, and the complicated procedures which were formerly employed are now seldom called for. This is largely due to the fact that patients submit themselves to operation while the rupture is still small, and before the structures forming the canal through which it emerges have been stretched and altered by the pressure of the protrusion.

HERNIOTOMY FOR INGUINAL HERNIA.—In the case of inguinal hernia, much more importance has come to be attached to the obliteration of the neck of the sac and less to the strengthening of the walls of the canal. It is now recognised that an important etiological factor in this condition is the existence of a pre-formed or congenital peritoneal sac. In the great majority of cases of inguinal hernia met with in children and in young adults, it is only necessary to deal with the sac, so little change having taken place in the canal that it spontane-



ously resumes its normal condition after the neck of the sac has been obliterated.

When, however, a hernia is of old standing, and has attained a considerable size, and particularly in persons over forty years of age whose abdominal muscles have commenced to lose their tone, the structures forming the wall of the inguinal canal become stretched and thinned out, and it is necessary to readjust them so that a recurrence of the protrusion may be prevented.

An incision is made parallel with the inner half of Poupart's ligament in the line of the inguinal canal, or obliquely intersecting it. The scar is less evident if the incision is made in the interspinous fold, its centre being opposite the internal abdominal ring. The superficial epigastric vessels and a few subcutaneous veins are divided and secured with forceps. After the superficial fascia and fat have been divided, the shining aponeurosis of the external oblique is exposed, and the canal is opened by slitting the aponeurosis in the line of the canal, and holding aside its edges with forceps. The horizontal fibres of the internal oblique attached to the outer half of Poupart's ligament are exposed, and Poupart's ligament is cleared by gauze dissection until the lowest part of the shelving edge is defined.

The spermatic cord, accompanied by the sac of the hernia, is seen emerging from the lower edge of the internal oblique, covered by the cremaster fascia, derived from the lower border of that muscle. The lower edge of the internal oblique is then cleared so that it can be retracted upwards and outwards, and the cremasteric covering of the cord is divided. The innermost covering of the cord—the infundibuliform fascia—derived from the transversalis fascia, is seldom recognisable except in children.

The sac can be recognised by spreading out the cord and looking at it against the light. It is usually possible

to clear the sac by gauze dissection as far up as the internal ring, and the neck of the sac can generally be recognised by a collar of yellow fat coming into view.

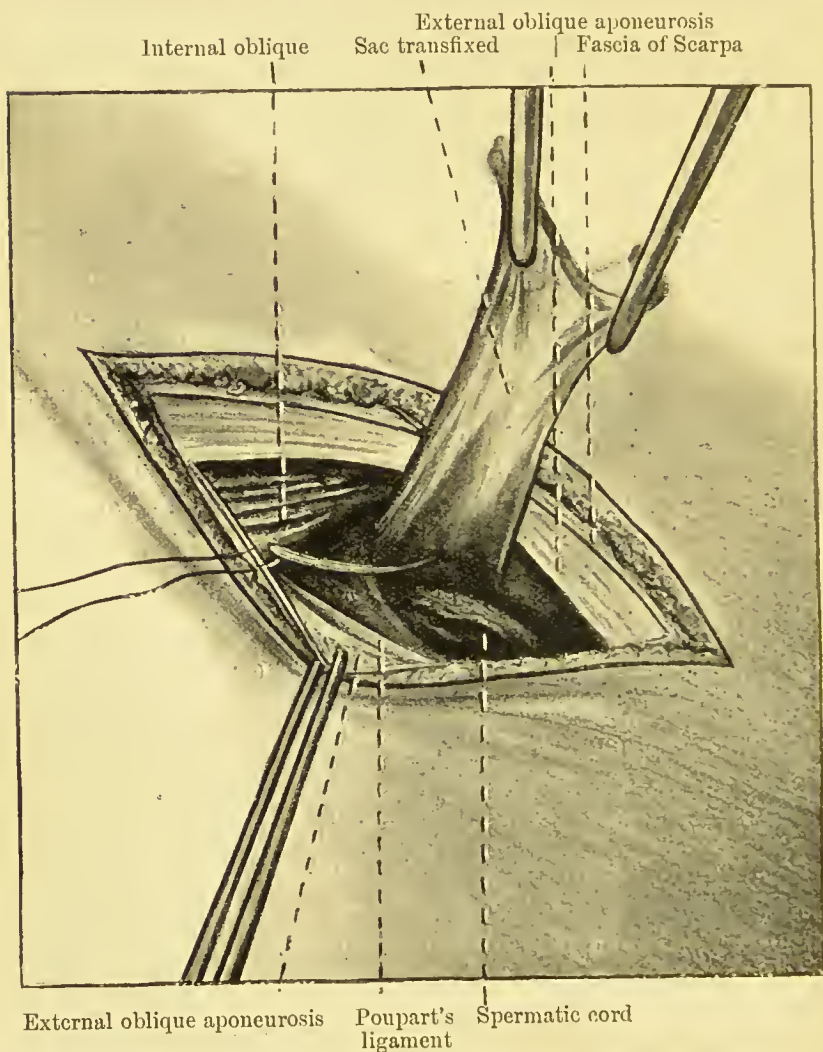


FIG. 200.—Operative Cure of Inguinal Hernia, obliterating the Neck of the Sac.

**Methods of Dealing with the Sac.**—There are several ways of disposing of the sac after its contents have been reduced. It may, for example, be transfixed at its neck

by a catgut stitch (Fig. 200), securely ligated, and cut off, the stump receding by its own elasticity under cover of the

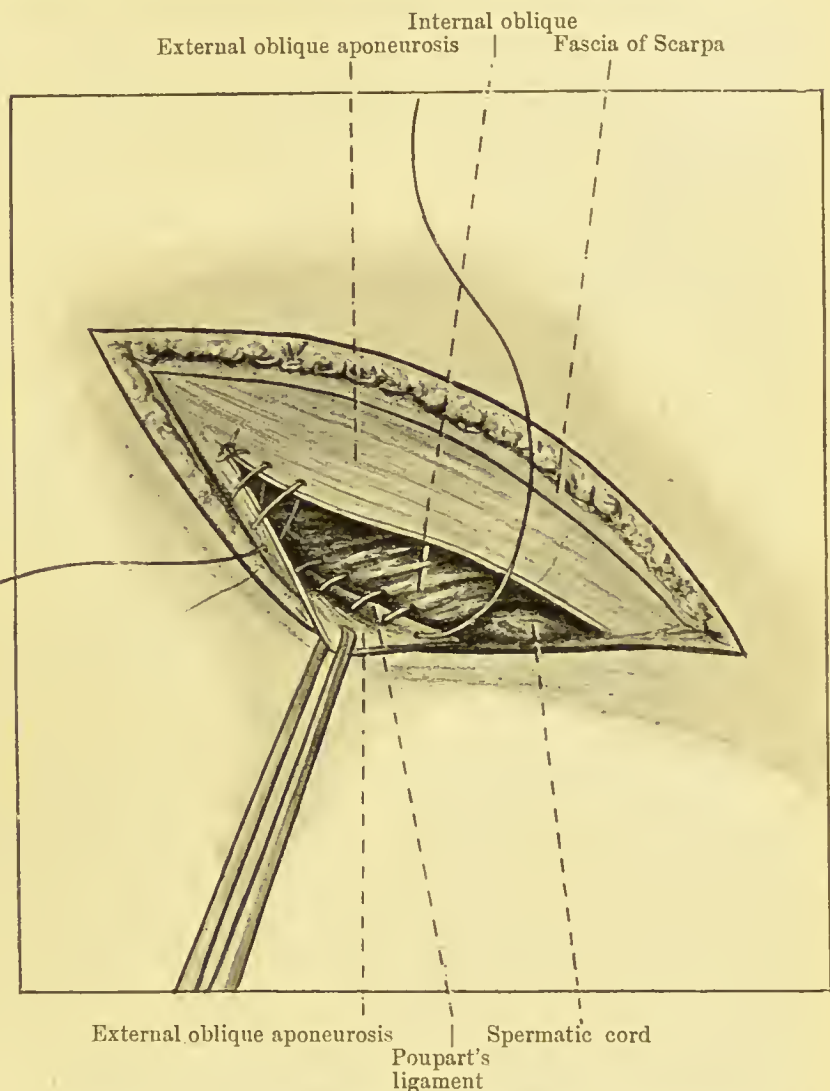


FIG. 201.—Operative Cure of Inguinal Hernia. Closure of the Inguinal Canal.

internal oblique. Kocher's plan consists in grasping the fundus of the sac with toothed forceps, invaginating it backwards along the inguinal canal and bringing it out through the external oblique aponeurosis at a point

opposite the internal ring, where it is anchored by means of a catgut stitch, and the excess of sac cut off. We have found it more convenient to push the forceps through the external oblique aponeurosis and pass them down the canal and out through the external ring, grasping the sac, pulling it back, and anchoring it where it emerges.

The slit in the external oblique aponeurosis is sutured by a continuous catgut stitch, and the wound closed.

**Methods of Reconstructing or Reinforcing the Inguinal Canal.**—When it is considered necessary to strengthen the walls of the canal in attempting to effect a radical cure in inguinal hernia, one or other of the following methods may be selected according to the requirements of the individual case. In the male, complete obliteration of the canal is not possible, as provision must be made for the passage of the spermatic cord. In very large herniæ it is sometimes justifiable to sacrifice the testis in order that the canal may be completely closed (Kocher), or to reduce the testis into the abdomen along with the contents of the sac (Bernhard).

(a) If the aponeurosis of the external oblique has already been incised in order to reach the neck of the sac, the internal oblique and transversalis muscles and their conjoined tendon are united to the abdominal aspect of Poupart's ligament by a stout chromic catgut suture (Fig. 201), and the edges of the externa loblique aponeurosis are brought together by a continuous suture. If the aponeurosis has been overstretched, the surfaces are made to overlap by a series of mattress sutures.

(b) *Bassini's method* of dealing with the canal (Fig. 202) consists in raising the cord from its bed, and pulling it forwards, while the internal oblique and conjoined tendon are sutured to Poupart's ligament beneath it. The cord is then laid on these structures and the external oblique aponeurosis is sutured over it.



(c) *Halsted* recommends that the size of the cord be diminished by resecting the pampiniform plexus, and that it be placed between the external oblique and the skin.

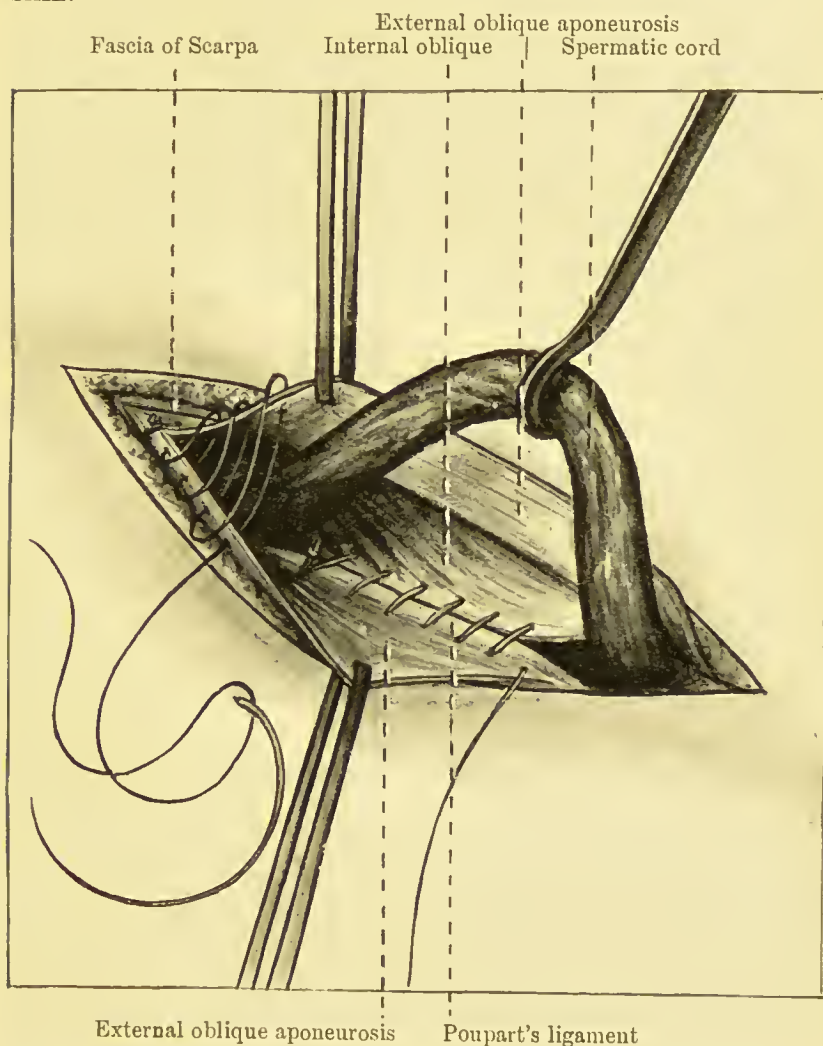


FIG. 202.—Operative Cure of Inguinal Hernia. Closure of the Canal by the Method of Bassini.

**Operation for Large Irreducible Herniæ.**—The conditions under which this operation are undertaken render it one of considerable severity and danger. The patient



is usually advanced in years, and as the operation is rendered necessary by threatenings of strangulation, the procedure is of the nature of a hernio-laparotomy. The abdominal wall and the coverings of the hernia are laid freely open, so that the exposure of parts in the region of the neck of the sac is ample. Adherent omentum is separated from the inside of the sac and the margins of the internal ring, care being taken that all vessels are secured before it is returned to the abdomen. It is often advisable to remove a considerable part of the omentum, and it may be necessary to establish an anastomosis between adjacent viscera or even to resect a portion of intestine. The peritoneum at the neck of the sac is closed by suture, and the wall of the canal re-formed by one or other of the methods above described. Kocher recommends for cases of this kind that a flap be raised from the rectus muscle, and the anterior layer of its sheath reflected outwards and stitched so as to strengthen the canal. Wire filigree, or a portion of fascia lata resected for the purpose, may be embedded in the tissues to strengthen the abdominal walls. It is particularly in this class of case that the removal of the testis facilitates the complete closure of the canal.

**Operation for Strangulated Inguinal Hernia.**—The line of incision through the integument and the aponeurosis of the external oblique is the same as is described above. This incision is deepened layer by layer over the upper part and neck of the sac until all its coverings are divided, after which it is usually found that on opening the sac it is possible to draw down the bowel so as to inspect its condition at the site of the constriction grooves. If the neck of the sac is so tight as to be the chief agent in causing the strangulation, it also must be divided so as to relieve the constriction and permit of the reduction of the contents. If the bowel is viable, it is gently compressed and returned. When two or more

loops of intestine are present in the sac, the most posterior loop should be replaced first. If the bowel does not appear to be likely to live, it must be resected. The operation is then completed by performing the radical cure.

**HERNIOTOMY FOR FEMORAL HERNIA.**—The anatomical arrangements at the femoral ring render the attempt to close the canal difficult and uncertain. The rigidity of the three sides of the ring formed by Poupart's ligament, the horizontal ramus of the pubis, and Gimbernat's ligament prevents efficient closure, and the presence of the femoral vein on the outer side forbids the use of sutures on this aspect.

The essential step in the operation is the **obliteration of the neck of the sac** at its highest point, and this can only be done by exposing it above Poupart's ligament.

A horizontal incision is made over Poupart's ligament, dividing the skin and superficial fascia; the lower edge of the wound is drawn downwards and the sac is shelled out from its surroundings. It is then opened, emptied of its contents, clamped where it enters the femoral canal, and the protruded portion is cut away. The upper edge of the wound is now retracted, exposing the external oblique aponeurosis, which is incised in a line parallel with Poupart's ligament. The internal oblique may also require to be divided and, with the help of suitable retractors, the neck of the sac is exposed. The deep epigastric vessels lie immediately to the outer side and must be avoided. The neck of the sac, having been isolated, is pulled out as shown in Fig. 203, transfixed by a catgut stitch at its highest point, and tied, and the stump is allowed to retract or, following Kocher's method, it may be turned inside out and displaced.

Of the numerous methods of attempting to **occlude the femoral canal** that have been devised may be mentioned that of Roux of Lausanne, who tacked

Poupart's ligament down to the pubis by means of metal staples; and that of W. H. Battle, who makes an incision upwards and outwards from the middle of the

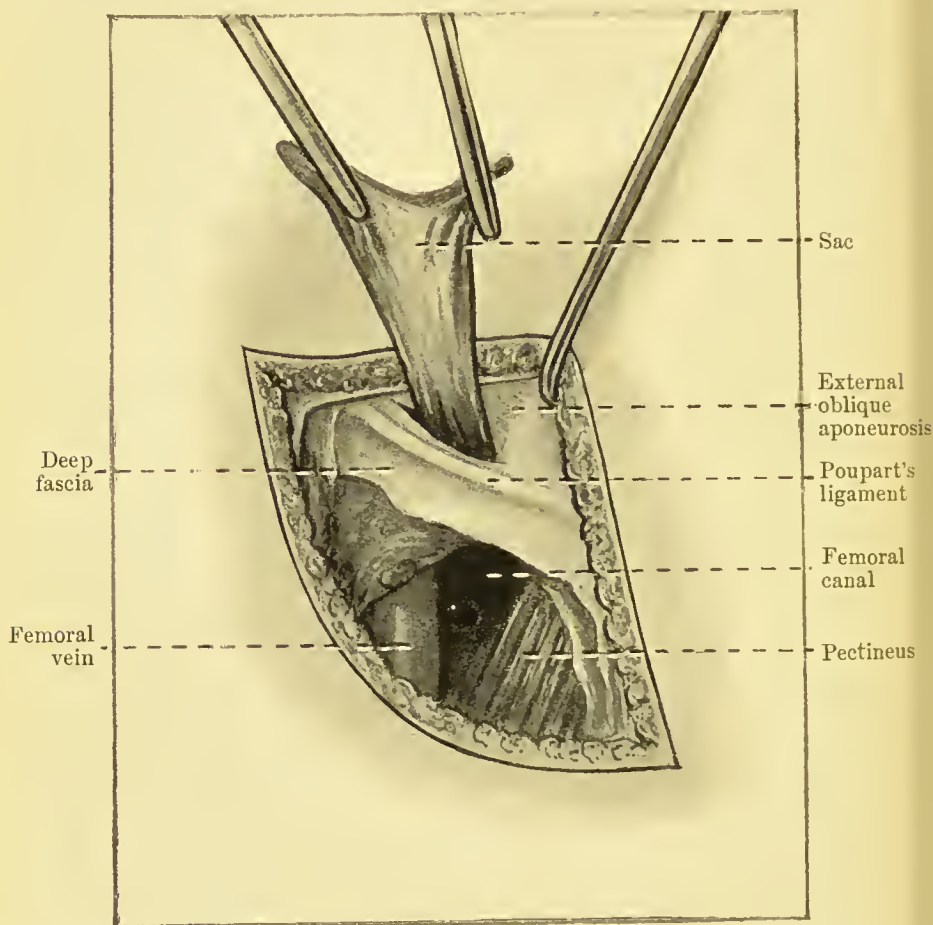


FIG. 203.—Operative Cure of Femoral Hernia; the Sac is exposed and drawn out above Poupart's Ligament.

external ring through the aponeurosis of the external oblique for about an inch and half, and slides the inner of the two flaps thus formed behind the outer and stitches it to Gimbernat's ligament, the pectineal fascia, and Poupart's ligament, so that it forms a "shutter"

over the femoral canal. The outer flap is then stitched to the aponeurosis of the external oblique.

Our experience of these and other methods leads us to agree with those who believe that little benefit follows any attempt to close the canal. The obliteration of the neck of the sac alone is seldom followed by recurrence of the hernia.

**Operation for Strangulated Femoral Hernia.**—After the sac has been exposed and isolated, a broad, flat director is passed along the canal between the neck of the sac and Gimbernat's ligament, and, with a hernia knife inserted along the groove of the director, two or more shallow nicks are made in the ligament, so that, in the event of an aberrant obturator artery being present, this will escape injury. The contents of the sac are drawn down to expose the part subjected to pressure opposite Gimbernat's ligament; if viable, they are returned to the abdomen and the sac is dealt with as already described.

**OPERATIVE CURE OF UMBILICAL HERNIA.**—The subjects of this operation are usually very stout women, with irreducible omentum forming the contents of the sac. Two horizontal semilunar incisions are made outlining the hernial tumour, and these are deepened through the fat, which may be several inches in thickness, until the aponeurosis is exposed for an area of several inches above and below the sac. The sac is then defined and opened, not over the summit where the coverings are thin and adhesions are most likely to be present, but nearer the neck. The intestine is returned to the abdomen, adherent omentum is dealt with on the usual lines, and the entire sac and overlying skin are cut away. W. J. Mayo completes the operation by making the upper edge of the opening overlap the lower as follows: a stout curved needle threaded with chromicised catgut, kangaroo tendon, or strong celluloid linen is passed from



without in through the aponeurotic structures and peritoneum from two to three inches above the margin of the opening. The needle and thread is drawn down and

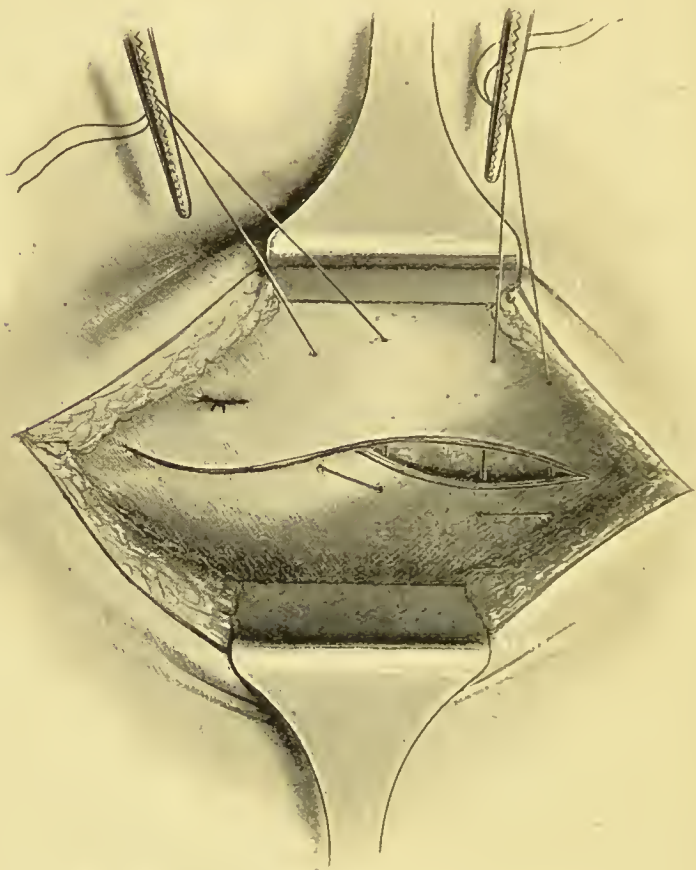


FIG. 204.—Mayo's Operation for Umbilical Hernia.  
Sutures introduced to overlap edges of aponeurosis.

out of the hernial opening. A firm mattress stitch is now caught in the upper edge of the lower flap, about a quarter of an inch from the margin; the needle is then carried back through the hernial opening into the peritoneal cavity and made to emerge a third of an inch lateral to the point of original entrance. On each side



of the first stitch is introduced a similar suture of strong chromicised catgut. The three sutures are drawn tight, pulling the entire thickness of the aponeurotic and peritoneal structures behind the upper flap. The margin of the upper flap is retracted to expose the suture line, and

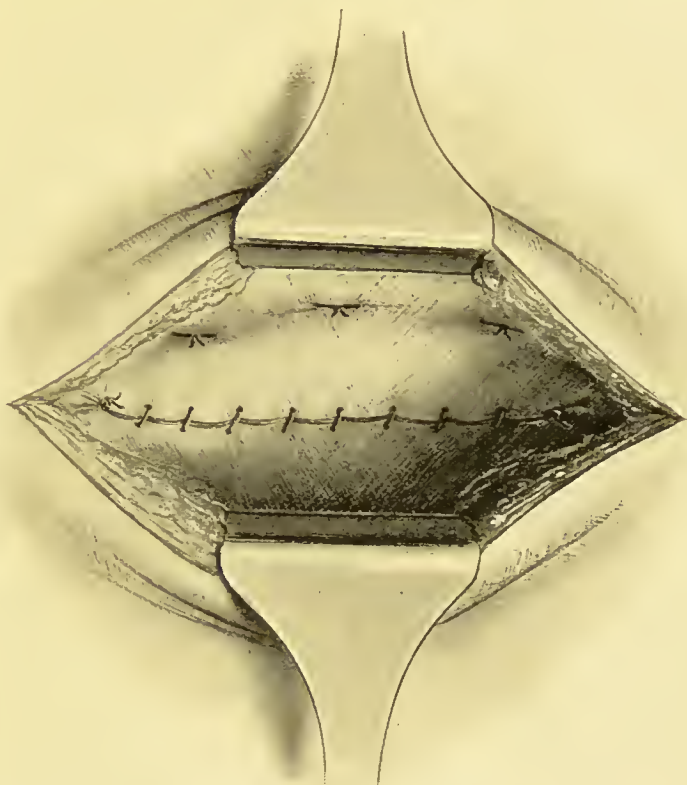


FIG. 205.—Mayo's Operation for Umbilical Hernia completed.

if any gap exists it is closed with catgut sutures. The upper flap is now sutured to the surface of the aponeurosis below by a continuous suture, and lastly the skin and fat are brought together. The patient is confined to bed from twelve to twenty days.

**THE OPERATIVE CURE OF VENTRAL HERNIA.**—This is most often required after operations for acute appendi-

citis in which drainage had to be provided for. The operation is a simple one, and consists in excising the scar tissue and reconstituting the abdominal wall by stitching the different layers individually to one another.

## CHAPTER XXXII

### OPERATIONS ON THE RECTUM

OPERATIONS FOR CANCER OF RECTUM AND LOWER END OF PELVIC COLON : *Perineal Operation of Lisfranc; Kocher's Coccygeal Operation; Combined Perineo-abdominal Operation.* OPERATIONS FOR HÆMORRHOIDS : *Ligature; Excision; Clamp and Cautery.*

#### OPERATIONS FOR CANCER OF THE RECTUM AND LOWER END OF THE PELVIC COLON

THE rectum is more frequently the seat of cancer than any other part of the gastro-intestinal tract except the stomach. Although the disease is nearly always within reach of the examining finger, in the majority of instances the nature of the condition is not recognised at a stage that permits of radical cure by operation. Owing to the anatomical situation and relations of the rectum, the technical difficulties of radical operation, especially in the male, are considerable, and in stout or muscular subjects the access to the upper and middle portions leaves much to be desired.

The main artery of the rectum is the superior hæmorrhoidal, which is the direct downward continuation of the inferior mesenteric artery. It enters the mesentery of the pelvic colon (Fig. 208), crosses in front of the left common iliac artery, and at the level of the third piece of the sacrum divides into two branches, which pass downwards under the fascia on either side of the rectum and anastomose with the middle hæmorrhoidals, derived from the vesical branch of the anterior

division of the internal iliac, and with the inferior hæmorrhoidals derived from the internal pudic.

The lymphatics of the lower rectum first pass laterally with the middle hæmorrhoidal vessels and then converge posteriorly and accompany the superior hæmorrhoidal in the meso-colon. It is therefore necessary in operating for cancer to remove the entire chain of glands with all the fat as high as the promontory of the sacrum. Above the promontory, the lymphatics follow the blood vessels in the meso-colon to the deep lumbar chain of glands. The lymphatics of the anal canal and anus also send tributaries to the glands in the groin.

Statistics show that recurrence is more frequent in the bowel or its immediate vicinity than in parts at a distance, hence the necessity for free removal of the parts that are the seat of the primary growth. The whole circumference of the affected segment, together with at least two fingers' breadth of the bowel above and below, must always be removed. It is never permissible to excise a portion of the wall of the gut when operating for cancer.

As septic infection is the chief cause of death after operations for cancer of the rectum, the measures taken to prevent or minimise this risk must be thoroughly carried out. In preparing the patient all purgation should be completed forty-eight hours before operation, after which the bowels are to be kept at rest, if necessary under the influence of bismuth and opium, and nothing is to be given by the mouth except teas or broths, and albumin water. The question of a preliminary colostomy may still be said to be unsettled. In practice its performance is becoming more and more restricted to cases in which there is such narrowing of the lumen of the diseased portion of gut that its efficient cleansing is impossible by other means.

We shall describe three types of operation: the peri-

neal operation of Lisfranc; Kocher's coccygeal method for cancer in the ampulla; and the abdomino-perineal method associated with the name of Quénu.

**The Perineal Operation of Lisfranc.**—This operation is intended for cancers which involve the anus, the anal canal, and the lowest part of the rectum, and the upper edge of the growth must in any case be within easy reach of the finger. The operation aims at removing the lower end of the rectum and the anal canal, with the surrounding muscles, fat, and lymph glands, from the coccyx to the prostate.

With the patient in the exaggerated lithotomy position, a circular incision is carried round the anus through healthy skin, and the ring of skin surrounding the anus is dissected up and stitched over the orifice so that it is securely closed. The outer skin edges are then drawn apart with retractors, and the posterior attachments of the external sphincter and of the levatores ani to the coccyx are divided. The left forefinger is now passed beneath the levator ani first on one side and then on the other, and the muscle divided with scissors curved on the flat. In front, the external sphincter is detached from the central point of the perineum, and the dissection is deepened, separating first the anal canal and then the rectum from the bulbous and membranous portions of the urethra, for the protection of which an instrument is passed into the bladder. The recto-urethralis muscle is then divided, and the bowel separated from the prostate, part of this structure being sacrificed if the growth is adherent to it. In women, the posterior vaginal wall, if adherent, must be sacrificed.

As the dissection proceeds on the lateral aspects, bundles of vessels supported by connective tissue are met with running inwards to the rectum, and are tied before being divided.

The rectum, being now completely separated, is



clamped by two crushing forceps at least two fingers' breadth above the edge of the tumour and divided between them, preferably with the thermo-cautery. The portion excised is laid aside, and before the upper clamp is removed the wall of the rectum is stitched all round to the perianal skin, strips of rubber tissue being packed in on either side, and some packing may also be introduced into the bowel. As healing takes place in part by granulation, there results a long canal surrounded by scar tissue, which, except when the motions are fluid, gives something approaching control. In some cases the tendency to stenosis is so decided that periodic stretching may be called for.

**Kocher's Coccygeal Operation.**—This operation is appropriate in cases of cancer confined to the ampulla of the rectum, and in which the anal portion is intact. It is being more and more practised in preference to that associated with the name of Kraske of Freiburg, in which a portion of the sacrum is sacrificed. Our only objection to the Kocher and Kraske type of operation is that no adequate information is obtained as to the condition of affairs on the peritoneal aspect of the pelvic floor, and it is probably the case that many persons are subjected to this operation when it is of no value because of the presence of peritoneal, lymphatic, or hepatic metastases, which preclude the possibility of a radical cure.

The patient is placed in the exaggerated lithotomy or in the right semi-prone position. The anus is closed with a subcuticular, circular suture, which is tied very tightly. The incision begins one inch behind the anus, and is carried back in the median groove on to the sacrum. The dense fascia covering the coccyx is divided and is stripped off close to the bone. The latter is then cut through at its base with bone-pliers (Fig. 206).

The ano-coccygeal fascia is split in the middle line, avoiding the transverse fibres of the sphincter, and the

portion of the levator ani that crosses behind the rectum, which is of importance in preserving control of the anus. This fascia gives attachment to the levator ani, the ischio-coccygens, and the coccygeus muscles, all of which are pushed aside along with it so far as their attachments to the coccyx are not already separated.

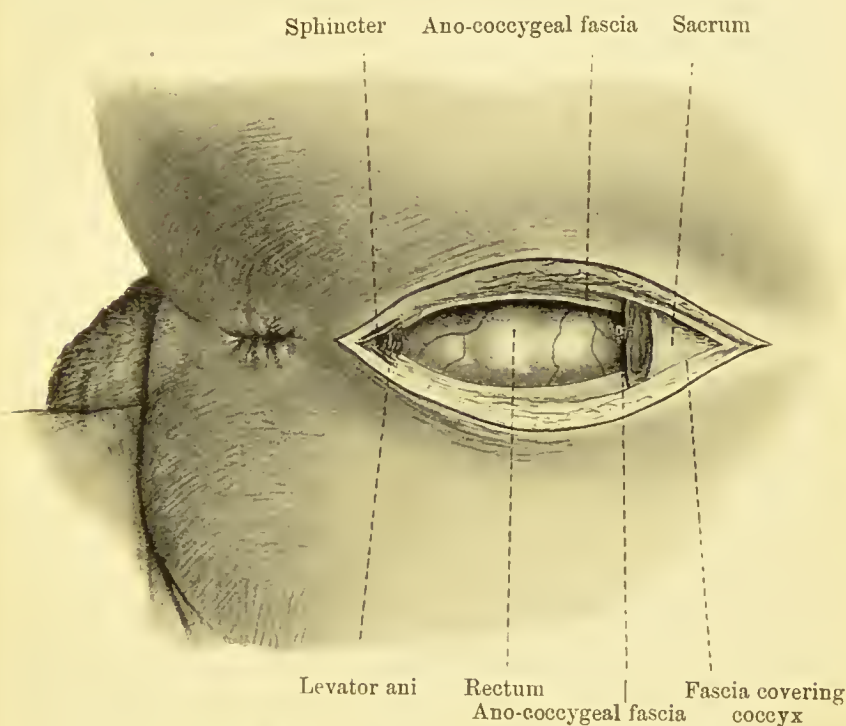


FIG. 206.—Kocher's Coccygeal Operation, 1st stage.

When the fascia has been sufficiently divided and separated, blunt dissection with the fingers is commenced, not keeping close to the rectum, but removing the surrounding fat and glands behind, and separating the bowel from the sacrum and on either side from the fascia covering the obturator internus muscle until the fingers can be passed right round the bowel.

The lateral bundles of connective tissue, which are rich in fat and contain the vessels, and which help to

hold the rectum in position, are hooked up on the finger and ligated on the proximal side with the aid of an aneurysm needle; forceps are then applied on the distal side, and the tissue is divided between the forceps and the ligature.

The pouch of Douglas is opened into on one side during the lateral dissection, and it is advisable to expose and open the peritoneum as early as possible.

By introducing the finger where the peritoneum has been opened on one side and passing it round in front of the rectum, the other side can easily be opened, after which the peritoneum may be freely divided in front. Forceps are then applied to the edges of the peritoneum, which are subsequently to be sutured. The rectum can now be pulled down much more easily (Fig. 207), the lateral bundle of vessels from the superior hæmorrhoidal artery can be put on the stretch, ligated on the proximal side, and caught with forceps on the distal side. A loop of gauze is passed round the rectum and used to pull it down. The pelvic colon can now be easily displayed, the upper part of it being covered with peritoneum and showing appendices epiploicæ.

If enough cannot be pulled down to admit of the bowel being clamped well above the growth, the vessels higher up in the meso-colon are hooked down from behind and divided between ligatures. It must now be determined whether the healthy colon above is sufficiently free to allow of its being brought down to the anal ring without tension. Two pairs of crushing forceps are then applied well above the disease, and in the groove left after removing the upper pair a strong silk ligature is tightly tied, after which the gut is divided with the thermo-cautery between the ligature and the lower pair of forceps.

The bowel, together with the new growth, is now drawn backwards, covered with gauze, and completely

freed by blunt dissection and scissors as far as the anal portion. In women this is usually easy, but in men an instrument must be passed along the urethra to render safer the dissection from the prostate.

After all bleeding has been arrested two pairs of crushing forceps are applied to the anal portion of the

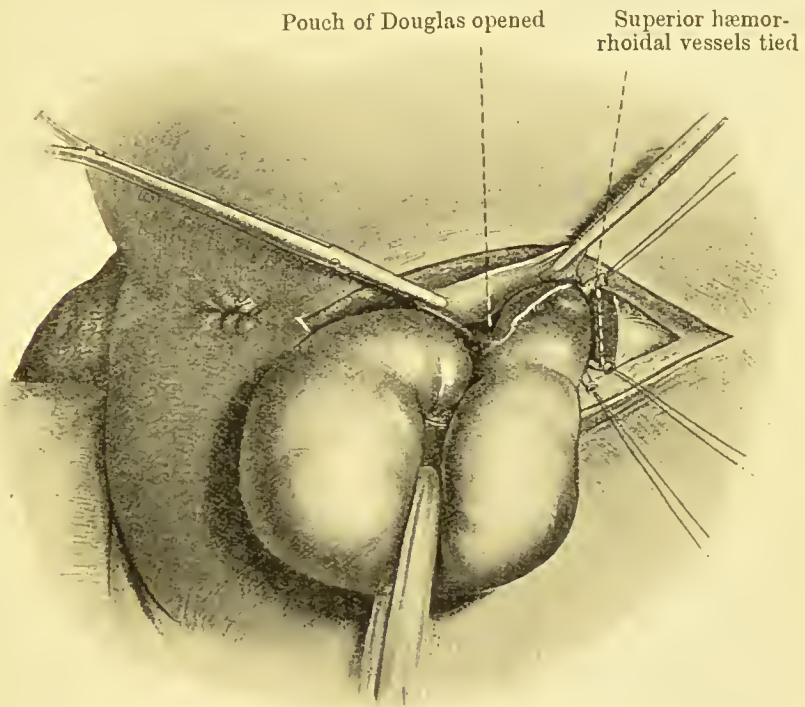


FIG. 207.—Kocher's Coccygeal Operation, 2nd stage.

gut well below the tumour and the bowel is cut across between them, thus completing the excision. The suture introduced at the commencement of the operation to occlude the anus is now cut, and the anal canal is dilated with the finger. The upper end of the bowel is now pulled down by means of the ligature previously applied to it, so that it is partly invaginated into the anal portion, to which it is stitched by a double row of sutures, and this must be done without the slightest



tension so as to avoid the risk of grangrene from interference with the blood supply, and, to ensure firm union, the sutures ought to be passed through the whole thickness of the gut. The mucosa of the anal canal should be preserved intact, as it is essential for maintaining the reflex mechanism of defæcation. The posterior wound is next packed with gauze. The ligature securing the upper end of the gut may now be removed, or it may be left in position for twenty-four or forty-eight hours.

In weak subjects we have found it advantageous to perform this operation in stages, after the manner of resecting the colon by the method of Mikulicz. The rectum and pelvic colon along with the tumour having been entirely freed from their surroundings, but being still in continuity with the bowel above and below, are brought out at the wound in the form of a loop, the two limbs of which are united to one another with catgut sutures. The loop is enveloped in a sheet of dental rubber and the rest of the wound is packed. Some days later the bowel containing the tumour is removed with the thermo-cautery, and after a further interval the open ends are brought together. There can be no doubt that this method saves bleeding and diminishes not only the shock but also the risk of septic infection. There is also much less risk of gangrene.

**The Combined Abdomino-perineal Operation.**—In cases of cancer involving the upper part of the rectum and the lower part of the pelvic colon, this operation, although a severe one, presents many advantages. One of the chief of these is that, as the first step consists in opening the abdomen, it is possible to make a thorough examination of the interior of the pelvis, to determine the upper limits of the growth, and to discover whether or not the lymphatics and peritoneum are infected. It can thus be decided at the outset whether an attempt should be made to perform a radical operation, or



whether one should be content with a palliative colostomy. Quénu, in 1897, was largely responsible for introducing this operation, but his original proposal that both internal iliac arteries should be ligated before proceeding to remove the bowel has not been accepted. The operation may be completed at one sitting, or it may be performed in two stages,—the intraperitoneal portion being done one day and the perineal portion some days later.

The patient is placed in the Trendelenburg posture, the abdomen is opened by an incision made in the middle line from the umbilicus to the pubes, and a self-retaining abdominal retractor is placed in position. If the access is still inadequate, and this is apt to be the case in the male, the recti muscles may be cut across. The next step consists in exploring the pelvis, and examining the liver for secondary deposits (Charles Mayo) to decide whether the case is suitable for the radical operation.

If it is decided to proceed, the small intestine is packed aside and the pelvic colon drawn out at the wound and divided between two clamps, usually at the level of the promontory of the sacrum. The meso-colon is divided sufficiently to permit of the upper end of the gut, after its stump has been ligated and invaginated, being brought out through a special opening in the left iliac fossa, with the object of forming a permanent artificial anus.

The lower end of the gut is also securely closed, so as to prevent leakage from it during the subsequent steps of the operation. It is wrapped in gauze and is drawn forwards to put the superior hæmorrhoidal artery and vein on the stretch, and these vessels are divided between two ligatures as they lie in the lumbo-sacral part of the meso-colon.

The peritoneum is next divided by incisions which

extend down into the pelvis, one on either side of the parietal attachment of the pelvic meso-colon and at least half an inch distant from it, until the recto-vesical pouch is reached, when they are carried round the lateral aspects of the pelvic wall to meet again in front just behind the base of the bladder.

By blunt dissection with the gloved fingers, the colon, together with the fat and glands, are stripped downwards from the hollow of the sacrum as far as its junction with the coccyx, and in doing this the middle sacral artery may be seen and ligated. A similar blunt dissection is carried out anteriorly, and the parts to be removed are thus detached from the bladder as far as the prostate.

In separating the lateral attachments of the gut, care must be taken to avoid injuring the left ureter, which adheres closely to the peritoneum as it skirts the wall of the pelvis. The lateral ligaments and middle hæmorrhoidal vessels are divided, and the resection is completed down to the upper surface of the levatores ani. All the detached structures are now displaced into the lowest part of the pelvis and are covered with large pads of moist gauze, and the wound in the abdomen is closed. If the operation is to be done in two stages, the separated bowel is covered with a sheet of rubber dam, and the peritoneal cavity may be shut off at once, the bladder in the male being utilised in doing so. The artificial anus is established in the left iliac region.

If the operation is to be completed at once, the patient is now placed in the lithotomy position, and, after the anal orifice has been closed with a circular suture, a deep incision is carried round the anal margin, and the perineal portion of the rectum, with its muscles and fat, is dissected free from the urethra and prostate, or from the vagina. This dissection extends up to and through the levatores ani, which form the boundary between the

upper and lower dissections, until the surgeon is able to grasp the parts separated above and remove them through the lower wound.

The perineal wound is narrowed down so that there is only room for a drain of rubber tissue. The surgeon, after changing his gloves, re-opens the abdominal wound, and with the greatest possible care covers over the surfaces which have been deprived of peritoneum, otherwise when coils of small intestine return to the pelvis adhesions are liable to form and lead to intestinal obstruction. What remains of the sigmoid loop is placed over part of the raw surface, and in the female, the body of the uterus and the broad ligaments are adjusted so as to aid in covering the gap. The artificial anus is then established and the mesial abdominal wound is closed.

The same operation may be undertaken without forming a permanent artificial anus in the abdominal wall, although hitherto this modification has been attended with a slightly higher mortality. If the colon is to be brought down to the normal position of the anus certain points must be attended to. After the abdomen has been opened and the small intestine packed off, it is important to ligate the inferior mesenteric artery between the origins of the left colic and the sigmoid branches (Fig. 208), as the latter are of great importance in maintaining the anastomosis in the mesentery of the colon which is to be displaced.

There is some difference of opinion as to how the inferior mesenteric should be exposed. Moynihan and others divide the left layer of the meso-colon and strip the mesentery and bowel inwards. We have found it easier to divide the right layer of the meso-colon. Fig. 208 shows the exposure not only of the inferior mesenteric artery and its branches, but also the left ureter. The opposite layer of the meso-colon remains to be divided and then the site of division of the colon

is determined upon, necessarily well above the disease, usually opposite the promontory. It is doubly clamped and divided, and both stumps are ligated and invaginated and wrapped in gauze. The steps for removal of the cancerous segment of the colon and rectum are the same as have already been described.

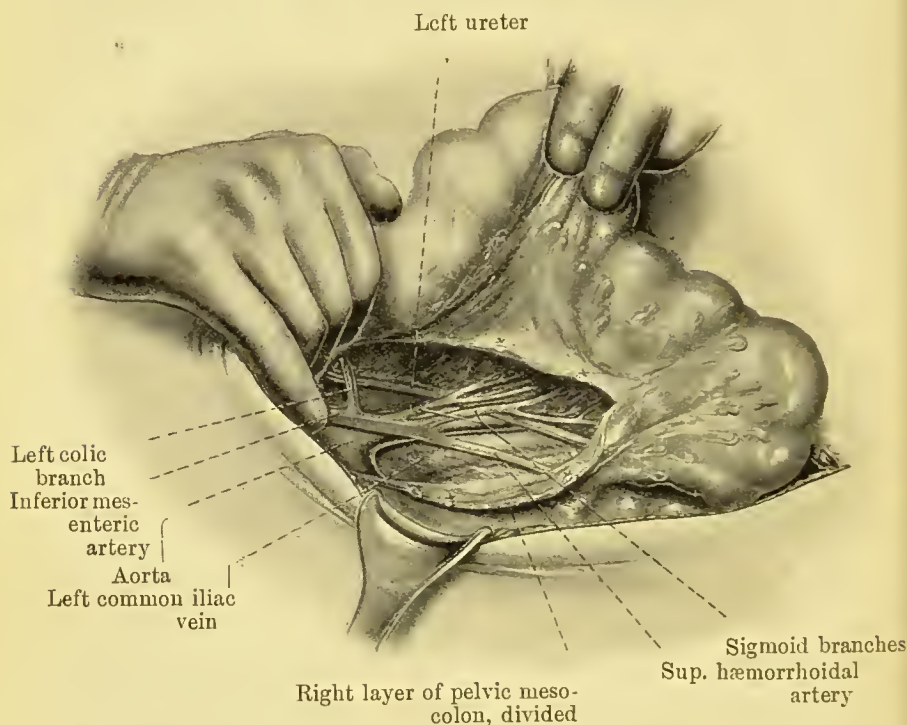


FIG. 208.—First Stage in Abdomino-perineal Operation. Exposure of Inferior Mesenteric Artery and Left Ureter.

(The body is lying on its back and the surgeon is looking from the right side.)

There is a choice of method in dealing with the parts that remain. The simplest is to bring the end of the colon out with forceps at the wound in the perineum and fix it to the skin in the natural position of the anus by several points of suture; the ligature closing it is not cut for two or more days. The alternative, when there is sufficient gut below for the purpose, is to join



the pelvic colon to what is left of the lower part of the rectum, and thus conserve to a greater extent the function of the lower bowel. The junction is best effected by the invagination method. A rubber tube three-quarters of an inch in diameter, with a lateral as well as a terminal opening, is passed through the anus and lower part of the rectum and into the open end of the colon for about three inches, where it is fixed by means of a lateral catgut suture half an inch above the cut end of the bowel. The end of the tube projecting from the anus is drawn upon until the cut ends of the bowel meet. Interrupted catgut sutures unite them end to end, special care being taken to co-apt the mucous membrane accurately. The tube is again pulled upon till half an inch of intussusception is produced, and a second row of sutures, sero-muscular this time, is inserted. The tube is left in position, and comes away of itself in from four to six days after the catgut has been absorbed (Donald C. Balfour, Rochester).

## OPERATIONS FOR HÆMORRHOIDS

It is only necessary to refer to three of the many operative procedures that have been suggested for the treatment of internal piles: ligation, excision, and clamp and cautery. Two or three days before the operation the bowels should be freely opened by castor oil, and no solid food should be taken thereafter. The evening before the operation the bowel should be washed out with a simple enema or with boracic lotion.

**The Ligature.**—This method is specially adapted to pedunculated piles. The neck of each pile is grasped by strong crushing forceps, and in the groove left after removal of the forceps a catgut ligature is securely tied. The remainder of the pile is then cut away with scissors.



If the pedicle is broad and there is danger of the ligature slipping off, the base of the pile may be transfixed with a catgut suture on a round needle, and tied in two halves or by a Staffordshire knot. Redundant folds of skin around the anus should be snipped off with scissors, and the skin edge stitched to the mucous membrane.

**Excision.**—The method we prefer is that suggested by Mitchell of Belfast, which consists in clamping the base of each pile with a pair of Kocher's artery forceps applied in the long axis of the bowel, and, after cutting off the redundant portion of the pile, introducing a continuous catgut suture which includes the clamp and the tissues around the base of the pile. Just before tightening up the suture, the clamp is removed. The suture not only arrests all bleeding, but also closes the wound, so that healing takes place more rapidly, and, no raw surface being left, the bowels may be encouraged to move from the third day.

**Excision of the Pile-bearing Area of Mucous Membrane.**  
—*Whitehead's Operation.*—After the piles are protruded, an incision is carried round the circumference of the anus separating the mucous membrane from the skin. The mucous membrane on one side is grasped with forceps and pulled down, and the whole pile-bearing area is separated from the submucous tissue by blunt dissection. As a rule, the varicose masses can easily be separated from the sphincter. When the upper limit of the piles is reached, the healthy mucous membrane is divided transversely, and is at once pulled down and stitched with interrupted catgut sutures to the anal margin. After the whole of the affected mucosa on one side has been removed and the healthy mucous membrane sutured to the skin around the anus, the other side is similarly dealt with.

The operation is attended with considerable loss of

blood, and when the piles are large and reach far up the bowel it may be followed by the formation of a circular cicatrix leading to stenosis of the anal canal. Whitehead's operation, therefore, should be restricted to specially selected cases.

**Clamp and Cautery.**—This method is specially applicable to cases in which the piles are friable and inflamed. Each pile is drawn down with forceps, and the clamp is applied at its base in a line radiating from the centre of the anus. The pile having been crushed by screwing up the clamp, the projecting portion is burned off flush with the blade by means of a cautery at a dull red heat. If there is any bleeding after the clamp is unscrewed, it should be tightened up again and the cautery re-applied.

After any one of these operations, a suppository containing bismuth and a quarter to half a grain of morphin is introduced into the rectum, and a dressing of gauze smeared thickly with vaseline applied and retained in position by a T-shaped bandage.

## CHAPTER XXXIII

### OPERATIONS ON THE LIVER

OPERATIONS ON THE LIVER: Access by Abdominal Route; by Transpleural route; Operations for Traumatic Lesions; Resection for Tumour; Operative Treatment of Cirrhosis.

ACCESS to the liver may be obtained from the front—the abdominal route, or from the side or posteriorly—the transpleural route.

**The Abdominal Route.**—Any of the incisions used to expose the gall bladder and bile ducts may be employed, preferably that which runs from the costal margin to the umbilicus, and the access may be improved by dividing the sixth and seventh ribs at their junction with their cartilages. In operating by this route for hepatic abscess, the affected portion of the right lobe of the liver is found to be projected downwards, and in the great majority of cases adhesions will have formed between it and the parietal peritoneum.

**The Transpleural Route** is indicated when access is desired to the upper part of the right lobe of the liver or to the right subphrenic space. The operation is described at p. 375.

**Operations for Traumatic Lesions of the Liver.**—In *penetrating wounds* it is usually necessary to enlarge the parietal wound to obtain sufficiently free access to arrest hæmorrhage, remove a foreign body, or repair any damage done to adjacent viscera. For *subcutaneous rupture*, the liver is exposed by one or other of the incisions already described.

The rupture having been exposed, the hæmorrhage may in some cases be temporarily arrested by compressing the vessels in the gastro-hepatic omentum between the fingers and thumb, one of these being passed into the foramen of Winslow.

To arrest the hæmorrhage permanently, if the bleeding vessels cannot be secured with forceps and ligated, the edges of the wound or tear should be brought together with a series of stout catgut sutures passed deeply through the liver substance with a round needle, and a few fine catgut or silk sutures passed through the torn capsule. If the bleeding cannot be stopped in this way, the wound in the liver must be firmly packed with long strips of gauze, the ends of which are brought out at the parietal wound. Sometimes a combination of suturing and packing is necessary.

**Resection of the Liver for Tumour.**—Resection of the liver for tumour should only be undertaken when the growth is primary and solitary, when its margins are clearly defined, when there is reasonable certainty that the whole of the tumour can be removed, and, in malignant cases, when a sufficient margin of healthy tissue can also be cut away to make recurrence improbable. In the majority of cases the growth is situated in the neighbourhood of the gall-bladder, and is secondary to the long-continued irritation of gall-stones.

The portion of the liver which is the seat of the growth is exposed by a free incision, and the surrounding parts are packed off with gauze. To secure a bloodless resection, several methods of operating have been practised. One of these is to pass a series of interlocking sutures through the liver along a line well beyond the limits of the growth. After the stitches have been tightly drawn, the liver substance is divided between the line of sutures and the base of the tumour. The cut edges of the liver are then brought together by deep sutures of thick catgut,

and a roll of dental rubber is fixed to the site of resection and brought out at the wound. Keen recommends the Paquelin cautery as the best means of dividing the liver substance.

The simplest of all methods is the excision of a wedge-shaped portion of the liver, the ligation of all the bleeding points exposed on the cut surfaces, and the approximation of these by deeply placed interrupted sutures. During the operation, the assistant controls the hæmorrhage by grasping the organ with one hand on each side of the line of incision, or by compressing the vessels in the gastro-hepatic omentum at the foramen of Winslow.

**The Operative Treatment of Cirrhosis of the Liver.—**

The treatment by operation of ascites due to cirrhosis of the liver was proposed by Talma of Utrecht, and was first successfully carried out by Rutherford Morison, in 1895. The object of the operation is to promote the formation of additional vascular anastomoses between the systemic and portal circulations, and this is attained by suturing the great omentum to the anterior abdominal wall, and by exciting the formation of adhesions between the liver, spleen, and parietal peritoneum. In all the adhesions so formed, vascular channels are soon established.

The abdomen is opened by an incision in or near the middle line between the xiphoid cartilage and the umbilicus. The ascitic fluid is allowed to escape, and what remains of it within the abdomen is mopped up with gauze, care being taken that no free fluid is left anywhere in the abdomen or pelvis. The upper surface of the liver is then brought into view, and is vigorously rubbed with gauze until a brisk reaction is excited, and the spleen is treated in a similar manner. The great omentum is either sutured with catgut to the parietal peritoneum, which is previously irritated by being rubbed with gauze, or it is brought out and inserted into a space made for it between the rectus muscle and the



posterior layer of its sheath. A drainage tube is inserted through a separate opening above the pubes to prevent the reaccumulation of fluid while adhesions are forming, but it must not be left in longer than a few days, as there is considerable risk of its allowing the entrance of septic infection. We have found it an advantage to insert the suprapubic drain as the first step of the operation. If the ascites relapses, recourse is had to tapping, and if this fails the operation may be repeated.

## CHAPTER XXXIV

### OPERATIONS ON THE GALL-BLADDER AND BILE DUCTS

PRELIMINARIES. OPERATION TO EXPLORE THE GALL-BLADDER AND BILE DUCTS. CHOLECYSTOSTOMY. CHOLECYSTECTOMY. CHOLEDOCHOTOMY: *Supra-duodenal*; *Retro-duodenal*; *Trans-duodenal*. CHOLECYST-ENTEROSTOMY.

THESE operations are performed to relieve mechanical obstruction to the passage of the bile, the most common cause of which is gall-stones, or to empty and drain infective accumulations in the gall-bladder or bile ducts.

The access to the deeper part of the gall-bladder and bile ducts is greatly improved if a firm cushion or sand-bag about 8 inches long, 6 inches wide, and 3 to 4 inches deep is placed behind the patient's back opposite the liver; the spine is thus pushed forwards and with it the liver, so that the bile ducts are brought several inches nearer the surface, and in a thin person may almost be brought up to the level of the wound. The opening out of the costal angle also tends to favour a downward movement of the intestines away from the liver (Mayo-Robson).

**Operation to Expose the Gall-Bladder and Bile Ducts.**—Of the various incisions available to expose the gall-bladder and bile ducts, we prefer one which passes from the costal margin opposite the angle between the ninth costal cartilage and the outer edge of the rectus obliquely downwards towards the umbilicus, because it

involves least danger to the nerve supply of the rectus muscle (Fig. 156).

Mayo Robson recommends a vertical incision in the middle of the right rectus, which may be prolonged upwards and inwards between the costal margin and the xiphoid cartilage if more room is required. Kocher's incision, which is made parallel with the costal margin and about two fingers' breadth from it, gives good access, but in our experience is more liable to be followed by hernia.

The peritoneal cavity having been opened, the colon, omentum and pyloric end of the stomach which present at the wound are displaced downwards and inwards, and packed off with large pads of gauze. A special pad of gauze is placed in the right kidney pouch, filling up the space between the abdominal wall on the outer side and the common duct and duodenum on the inner side. In many cases the further steps of the operation can be facilitated if the liver is displaced by first drawing it downwards from under cover of the ribs and then rotating it so that the under surface looks forwards, or forwards and upwards (Fig. 209). By this manœuvre the gall-bladder and the cystic and common ducts are not only brought much nearer the surface, but they are made to form a straight passage from the entrance of the cystic duct to the ampulla of Vater. The liver is maintained in this position by traction exercised by the assistant either on the fundus of the gall-bladder or on the liver itself.

The gall-bladder, the bile ducts, the pancreas, and other parts in the vicinity are then investigated, and according to what is found, the further procedure is decided upon.

After the intraperitoneal part of the operation has been completed, the pillow should be removed from beneath the back before the wound in the parietes is stitched.

**Cholecystostomy.** — This operation, which consists in opening the gall-bladder, usually for the purpose of establishing drainage of the bile passages, was first performed by Lawson Tait. If the gall-bladder is of normal size, and still more if it is distended, the operation is an easy one, as the fundus can be brought out at the wound, after which it is surrounded with gauze, or, still better, is pulled through an opening in the centre of a sheet of dental rubber, to diminish the risk of leakage of its contents into the abdomen. An exploring needle is thrust into the fundus, and the fluid contents are withdrawn. On either side of the puncture, the fundus is pinched up with catch forceps to steady the bladder and hold it forwards, and the needle puncture is enlarged with scissors until an opening half an inch to an inch in length is made. The forceps, which grasped the whole thickness of the bladder at each side of the puncture, are now removed, and re-applied so that only the edges of the opening are caught. If gall-stones are present, they are removed with the gall-stone scoop, and when all the stones that can be felt with the scoop have been removed, the forceps on the edges are crossed so as to close the opening, and the fundus is wrapped in gauze. The swabs that were placed beneath the bladder are now removed, and, while the bladder is held in the left hand, the fingers of the right hand are slipped along the under surface and the ducts thoroughly explored. If a stone is felt in the cystic or hepatic duct, an attempt is made to displace it into the gall-bladder. If any difficulty is experienced in doing this, the scoop should be re-introduced and manipulated under the guidance of the fingers outside. Finally, a large probe is passed along the ducts as far as the ampulla of Vater to ensure that the channel is clear. A thick-walled rubber tube about a third of an inch in diameter is pushed for about

two inches into the gall-bladder, and secured by a purse-string suture of catgut. The possibility of leakage taking place along the side of the tube is diminished if the wall of the bladder is invaginated as in a Senn's gastrostomy, by a second purse-string suture (Fig. 209), or by over and over stitches as in a Kader's gastrostomy. If the wall of the gall-bladder is thickened and con-

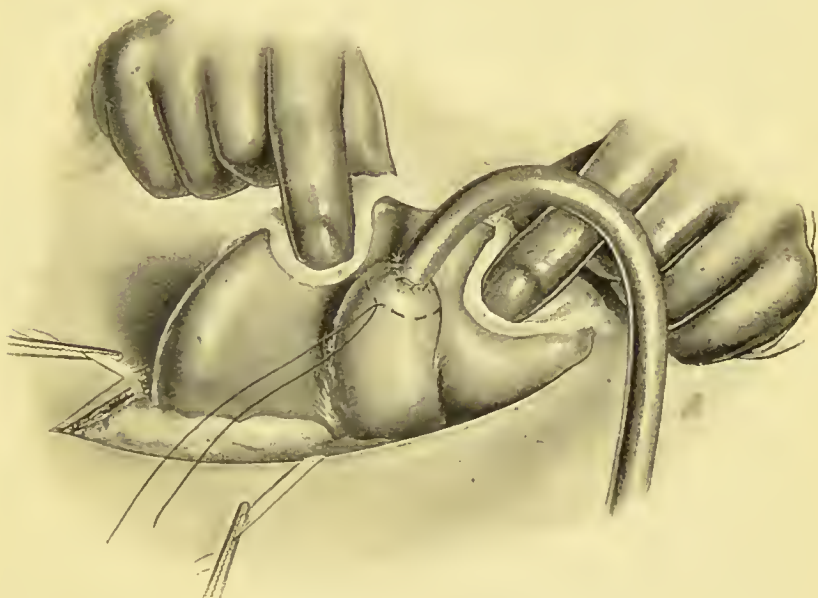


FIG. 209.—Cholecystostomy ; securing Drainage Tube in Fundus of Gall-Bladder.

tracted, it is impossible to carry out either of these procedures, and we have seen no drawback from omitting them, nor do we think it necessary to stitch the gall-bladder to the parietal peritoneum.

The tube is brought out through the dressing and drains the bile into a bottle beside the patient, and is retained from eight to fourteen days, according to the severity of the cholecystitis. Even when all the obstructing stones have been removed, the bile may not



flow freely at the conclusion of the operation, and sometimes one or two days may elapse before there is a free flow.

When a stone is very firmly impacted in the cystic duct, as forcible attempts to displace it entail the risk of rupturing the duct, it is better to cut down upon the stone directly and remove it through the incision. If possible, the opening in the duct is closed by sutures, and the tube used to drain the gall-bladder is passed beyond the opening in the duct. In some cases it is found necessary to lay the whole gall-bladder open on its under surface, in which case it is better to remove the gall-bladder than to attempt to drain it.

In long-standing cases of cholelithiasis, the operation for the removal of stones from the gall-bladder is often rendered difficult because of the shrunken, contracted condition of the bladder and the presence of adhesions binding it to adjacent viscera. In separating the adhesions, great care must be taken not to open up a fistulous communication between the gall-bladder and the stomach or intestine, from which leakage may take place and set up peritonitis.

As the contracted condition of the gall-bladder prevents it being brought to the surface, its wall must be incised where it is stretched over the stone. A rubber tube is then inserted and fixed in position, as already described. If there has been much separation of adhesions and leakage of the contents of the gall-bladder, a second tube should be inserted to drain the right kidney pouch.

**Cholecystectomy.**—The operation of excising the gall bladder is chiefly called for, when, on investigation, the cystic duct is found to be stenosed or obliterated. Excision having been decided upon, the removal of the gall-bladder may be commenced at either extremity. In the absence of adhesions, we prefer to commence the

dissection by isolating the cystic duct, which, along with its companion artery, is clamped with two pairs of forceps and cut between them. The right forefinger is then used as a blunt dissector to raise the gall-bladder from its bed, and, when it has been separated, the peritoneum on either side is divided with scissors about half an inch from its reflection on to the liver. The

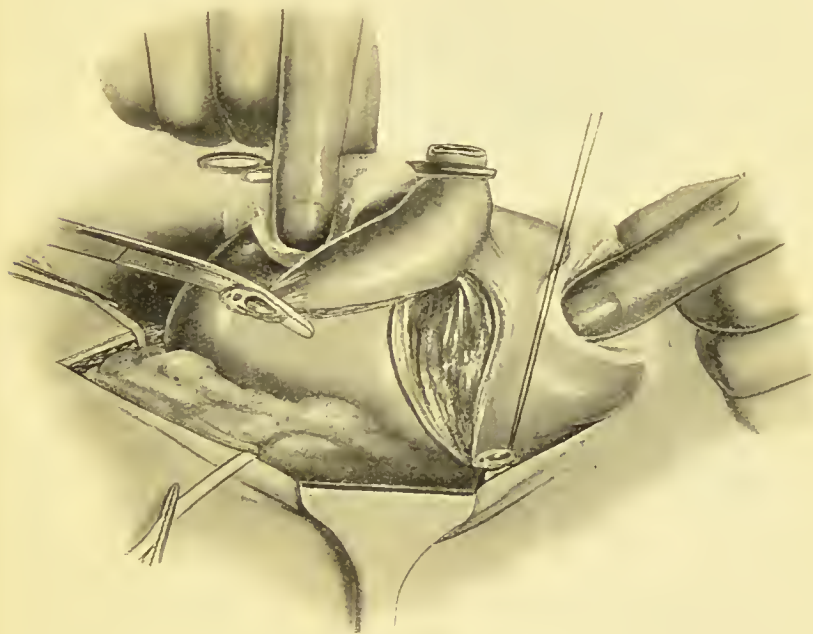


FIG. 210.—Cholecystectomy, 1st Stage.

cut end of the cystic duct and the cystic artery are ligated, and the stump is buried by bringing the cut edges of the peritoneum over it. The raw surface from which the bladder was removed is then covered in by bringing the cut edges of the peritoneum together with a continuous suture (Fig. 211). If, owing to the presence of infection, drainage is called for, a rubber tube is inserted into the hepatic duct through the stump of the cystic duct, and secured there by means of a purse-

string suture. In any case a drain should be inserted down to the closed end of the duct

**Choledochotomy.**—Choledochotomy, or incision of the common bile duct, is called for to remove an obstruction, usually gall-stones, or to provide drainage in cases of infective cholangitis. The duct may be exposed above

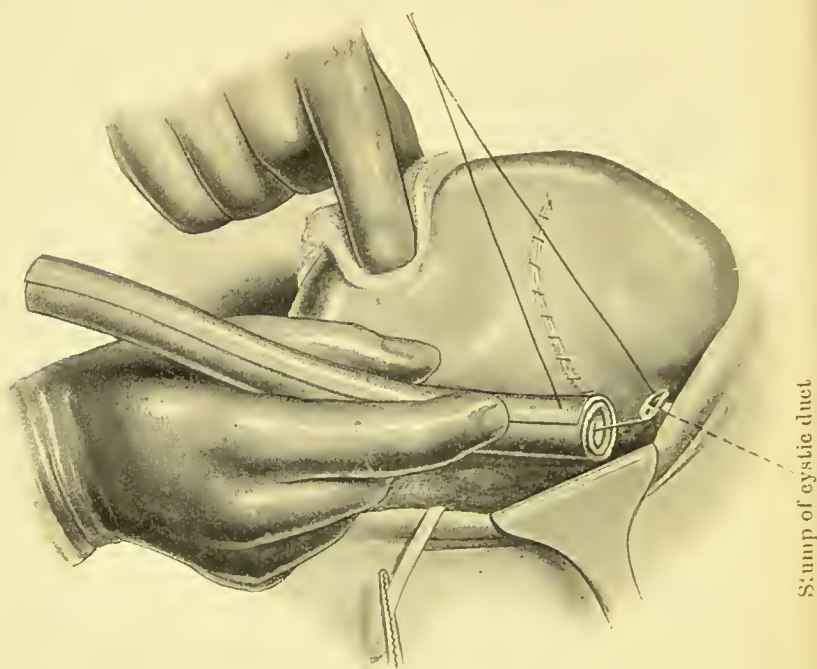


FIG. 211.—Cholecystectomy, 2nd Stage.

the duodenum, behind the duodenum, or from within the duodenum.

*Supra-duodenal Choledochotomy.*—The area of operation is freely exposed through one or other of the incisions already described. The colon, omentum, and stomach are packed off, adhesions are separated, and the liver is drawn downwards and forwards to bring the duct nearer the surface and into a straight line with the gall-bladder. The line of the duct is then explored with the fingers,

and if a gall-stone is felt, it is fixed between the fingers and thumb, and the wall of the duct incised in its long axis. After the stone has been extruded, the cut edges of the duct are seized with toothed-forceps, and a scoop, or, if the duct is sufficiently dilated, the finger also, is passed up and down the duct till it is certain that all the concretions have been removed. The bile that escapes during these manipulations, being infective, must be mopped up as it flows. Before the operation is completed, a large probe should be passed down into the duodenum to make quite sure that the passage is free.

Drainage is provided for by pushing a rubber tube along the common duct upwards into the hepatic duct, and fixing it in position by a catgut suture, which transfixes the tube and the cut edge of the duct. The remainder of the opening in the duct is closed with a fine catgut stitch, and the drainage tube is brought out at the lower part of the abdominal wound, or through a stab wound in the loin. A second tube may with advantage be employed to drain the right kidney pouch; this is removed in forty-eight hours, that in the bile duct in eight or ten days.

When a stone is so firmly impacted *in the hepatic duct* that it cannot be displaced either into the gall-bladder or common duct, it is cut down upon through the wall of the hepatic duct—*Hepaticotomy*.

*Retro-duodenal Choleldochotomy*.—This operation is indicated when a stone is impacted in the portion of the common duct which passes behind the duodenum. It is rarely called for, as it is nearly always possible to displace the stone into the supra-duodenal portion. The peritoneum is incised vertically an inch and a half or two inches to the right of the duodenum, and is then stripped by means of the fingers towards the middle line; it is now possible to turn the second



part of the duodenum over to the left and expose its posterior surface (Fig. 212). The stone impacted in

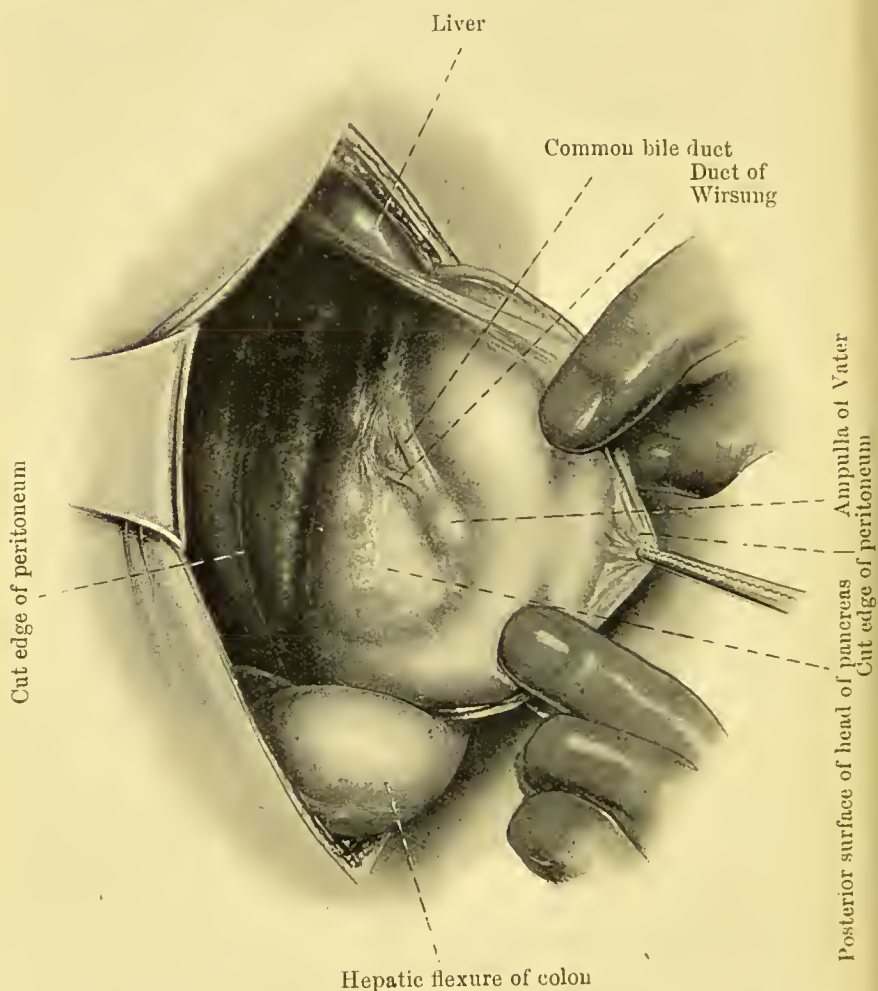


FIG. 212.—Exposure of Terminal Portion of Common Bile Duct and of Duct of Wirsung by Mobilisation of Duodenum.

the second portion of the duct is palpated, and the wall of the duct together with any overlying portion of the pancreas is incised, and the stone removed. The usual exploration of the common duct is carried out, and provision is made for drainage.



*Trans-duodenal Choledochotomy.*—The termination of the common duct, including the stone, is grasped between the fingers and thumb of the left hand, and the anterior wall of the duodenum is cut through vertically in order to expose the posterior wall from within, with the termination of the duct running in it. The position of the duct is readily identified by feeling the stone impacted in its lumen. The duct is laid open by slitting up the papilla with a probe-pointed knife, a procedure introduced by M'Burney, or the stone is cut down upon through the posterior wall of the duodenum as suggested by Kocher. Bile escapes freely as soon as the obstruction is removed, and must be mopped up as it flows. In M'Burney's operation no sutures need be placed in the posterior wall of the duodenum, but if Kocher's method has been employed, the incised margins of the duct and duodenum must be brought together by two or more stitches. The incision in the anterior wall of the duodenum is then closed in the ordinary way.

For calculi impacted in the ampulla of Vater we have found M'Burney's operation both easy and efficient. In stout patients the access is improved by mobilising the duodenum after the method introduced by Kocher.

**Cholecyst-enterostomy.**—This operation consists in establishing an artificial communication between the gall-bladder and the intestine. It is indicated when there is an obstruction to the flow of bile into the bowel by some condition which cannot be removed, such as chronic pancreatitis or stricture of the common duct.

The abdomen having been opened and the condition of affairs investigated, the gall-bladder is aspirated and brought into contact with the portion of intestine selected for the anastomosis, preferably the duodenum, and surrounded with the usual gauze packing. The anastomosis is made by simple suture, or, if preferred, with the aid of a Murphy button.

If it is impossible to anastomose the gall-bladder with the duodenum, a loop of jejunum may be selected and brought either over the hepatic flexure of the colon or through an opening in its mesentery. To prevent intestinal contents making their way into the gall-bladder, it is advisable to make a lateral anastomosis between the two limbs of the loop of jejunum employed.

The colon should not be employed, as there is greater risk of infection passing to the gall-bladder and liver.

## CHAPTER XXXV

### OPERATIONS ON THE PANCREAS

OPERATIONS ON THE PANCREAS : Anterior Operation for  
Pancreatitis ; for Pancreatic Cyst

To expose the pancreas for purposes of exploration, access is best obtained from the front. To establish drainage in suppurative conditions and in the treatment of pancreatic cyst, an incision is sometimes made in the loin ; the incision begins at the tip of the twelfth rib, and is carried obliquely forwards towards the umbilicus, the muscles being separated in the line of their fibres.

**The Anterior Operation.** — A sand-bag or pillow is placed behind the lower part of the thorax, and the abdomen is opened in or near the middle line above the umbilicus.

According to the nature and situation of the lesion, the pancreas is exposed either above or below the stomach. As a rule, the latter route is selected. The most direct access is obtained by dividing the upper part of the great or gastro-colic omentum. A portion of the omentum devoid of large blood vessels is chosen immediately below the greater curvature of the stomach, and an opening is made in it and enlarged sufficiently to open up the lesser sac of the peritoneum, behind which the pancreas is reached after the layer of peritoneum forming the posterior wall of the sac has been divided.

To expose the organ through the transverse mesocolon, the great omentum and transverse colon are

turned upwards, as in performing a posterior gastro-enterostomy, and the lesser peritoneal sac is opened by incising the meso-colon in an area devoid of blood vessels.

If an inflammatory or suppurative condition is found, the peritoneal cavity is packed off with gauze and the pancreas incised. Necrosed tissue is removed with the spoon or scoop, and the cavity packed with gauze. If there is an accumulation of blood, as in the hæmorrhagic form of pancreatitis, this is removed, and, to prevent further extravasation, the cavity must be firmly packed. If there is a collection of pus, provision must be made for drainage, either through the abdominal wound or through a separate opening made in the right or left costo-vertebral angle. If there is disease in the gall-bladder or bile ducts it must also be dealt with.

When the operation is performed for *pancreatic cyst*, the cyst is exposed by dividing the gastro-hepatic or the gastro-colic omentum as may be indicated. As extirpation is seldom possible, particularly when the cyst is in the head of the pancreas, before being opened its wall should be sutured to the parietal peritoneum, or, if it is too thin to admit of this, the peritoneal cavity must be packed off with gauze. After the cyst has been emptied, free drainage is provided for. A rubber tube may be introduced through the anterior wound and fixed to the edge of the cyst wall by a catgut suture, or a fresh opening may be made in the loin and a tube brought out through it, thus establishing a posterior drain. We have upon one occasion drained a cyst of the head of the pancreas by anastomosing it with the duodenum.

Cysts in the tail of the pancreas occasionally lend themselves to extirpation.

## CHAPTER XXXVI

### OPERATIONS ON THE SPLEEN

OPERATIONS ON THE SPLEEN : To Expose the Spleen for Rupture ; Splenectomy ; Splenopexy

**Operation to Expose the Spleen.**—The most generally useful incision to expose the spleen is one passing vertically downwards from the xiphi-sternum slightly to the left of the middle line, and if this does not afford sufficiently free access, an oblique cut may be carried from its lower part upwards and outwards (Fig. 156). A large incision is necessary, particularly when there are extensive adhesions, the presence of which may render the operation extremely difficult.

When the operation is performed for **Rupture of the Spleen**, the vessels at the hilum are at once grasped with the fingers to control the bleeding, and the clots which have formed in and around the lacerations are cleared away. If the rent in the spleen is superficial, the bleeding may be controlled by a series of catgut sutures passed deeply through the substance of the organ. As a rule, however, the rupture is so extensive that removal of the spleen is called for. The vessels at the hilum are secured with a clamp, care being taken that no undue traction is made on the pedicle, and that no portion of the tail of the pancreas is included in the grasp of the forceps. The pedicle is then ligated *en masse*, and divided at some distance from the ligature. After the spleen has been removed, the individual vessels



may be seized with forceps and tied separately. This is always advisable when the injured spleen was previously enlarged. Before the abdomen is closed, the adjacent viscera should be examined in case they have also sustained damage.

**Splenectomy for Enlargement or New Growths** is carried out on the same lines as for injury. The chief difficulties of the operation arise from the presence of adhesions, and from the fact that the spleen is very friable and is therefore liable to be torn in their separation. Special care must be taken in securing the pedicle, as the vessels are larger and more numerous than normally.

**Splenopexy.**—The object of this operation is to fix a wandering spleen. The method of choice is that of Rydygier, in which the spleen is fixed in an artificial space outside the peritoneum. The abdomen is opened to the left of the middle line, and the under surface of the diaphragm having been exposed, a horizontal incision is made through the peritoneum between the ninth and tenth ribs. By means of the fingers the peritoneum is separated from the diaphragm above and below this incision, until a pouch large enough to contain the spleen has been formed. Before the spleen is placed in the pouch, a continuous suture may be applied around the upper and lower margins to limit it, and a few supplementary stitches may be inserted to secure the organ in its new position.

## CHAPTER XXXVII

### OPERATIONS ON THE KIDNEY AND URETER

OPERATIONS ON THE KIDNEY: Operation to Expose the Kidney—Lumbar Operation; Nephropexy; Nephro-lithotomy; Nephrectomy—*Lumbar; Trans-peritoneal.*

OPERATIONS ON THE RENAL PELVIS AND URETER: Nephrostomy and Pyelostomy; Exposure of Ureter—*Upper End (Lumbo-renal); Abdomino-pelvic — Extra-peritoneal, Trans-peritoneal; Intra-vesical.* Ureteral Anastomosis; Implantation of Ureter—in *Bladder; in Intestine.*

**Operation to Expose the Kidney.**—In the great majority of conditions calling for exposure of the kidney, access is best obtained through the lumbar region. In the removal of a very large kidney, or when it is necessary to examine both kidneys before proceeding to deal with one, a trans-peritoneal operation is performed.

**Lumbar Operation** (Fig. 213).—The patient is placed on his sound side, with a firm roller pillow inserted between the last rib and the iliac crest to open up the loin on the affected side. The arm of the affected side should be supported by an assistant and not allowed to rest upon the thorax.

The incision is commenced posteriorly in the angle between the erector spinæ and the twelfth rib, and is carried downwards and forwards in a direction towards the anterior superior iliac spine, as far as the mid-axillary line. If more room is required, the incision is continued on wards, above and parallel with Poupart's ligament as far as may be necessary. When the space between the

ribs and the iliac crest is abnormally limited, the twelfth, and if necessary also the eleventh, rib may be divided or

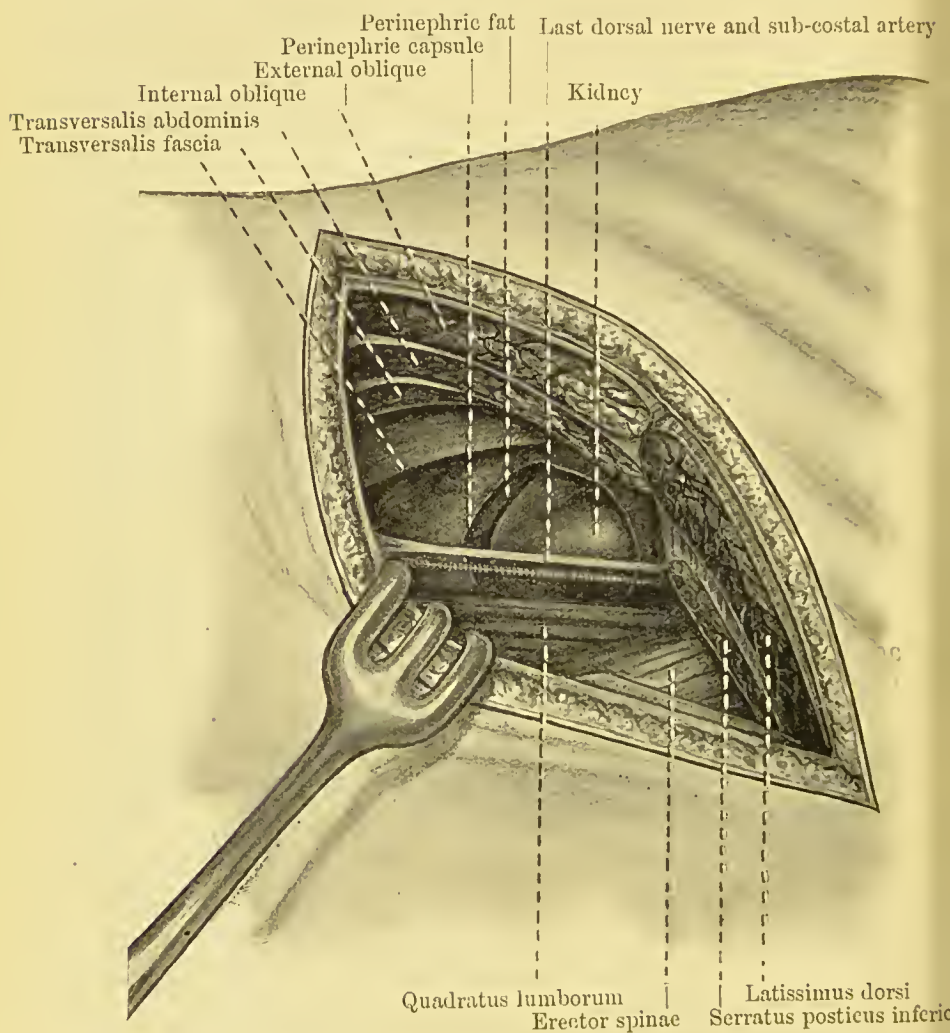


FIG. 213 —Exposure of Left Kidney by Lumbar Incision.

resected subperiosteally, care being taken, however, that the pleura is not injured.

The incision divides the skin and subcutaneous fat, the strong lumbar fascia, and the muscles arising from it—the latissimus dorsi, and under it the serratus

posticus inferior. The edge of the erector spinæ is drawn forcibly aside, or, if necessary, is cut. Farther forwards, the external and internal oblique muscles, and that portion of the transversalis which is attached to the lumbar fascia, are divided, each in the line of its fibres. After the lumbar fascia has been divided, the edge of the quadratus lumborum is seen passing almost vertically upwards parallel with the margin of the erector spinæ, beyond which it projects. The last dorsal nerve, accompanied by the subcostal artery, appears at the lower border of the twelfth rib and passes obliquely downwards and forwards, sometimes beneath, sometimes over the edge of, the internal oblique. The ilio-hypogastric nerve passes downwards and outwards from beneath the edge of the quadratus.

The transversalis fascia is now divided, and the loose fatty capsule of the kidney separated until the kidney invested in its proper capsule is exposed.

**Nephropexy.**—This operation, which consists in fixing an unduly movable kidney, was first proposed by Hahn in 1881. The usual dissection is made for exposure of the kidney from the loin, and the kidney is projected towards the wound by pressure made by an assistant through the anterior abdominal wall. It is then grasped by the operator's fingers, brought outside the wound, and packed round with gauze. The capsule is incised along the convexity of the kidney, and with the aid of the dissecting forceps and a blunt dissector is stripped off the kidney on either side. The detached capsule is then united by a number of sutures to the aponeurotic structures in its vicinity, care being taken that the organ is made to occupy its proper position. In passing the sutures, care should be taken not to include the last dorsal and first lumbar nerves. Sometimes the sutures are passed around the last rib, but this is attended with some risk of injuring the



pleura (Kocher). The passage of sutures through the renal substance is apt to cause extensive necrosis of the parenchyma, and is to be avoided.

To promote the formation of granulation tissue and so add to the security of fixation, the space around the lower pole of the kidney may be packed with gauze, which is left in position for about a fortnight. The end of the gauze is brought out at one corner of the wound.

In some cases we have found the construction of a shelf at the lower pole of the replaced kidney, as recommended by Harris and W. J. Mayo, effective. The shelf is formed by stitching the anterior and posterior layers of the perirenal fascia to the parietal peritoneum at the outer side of the colon, and to the aponeuroses of the abdominal wall.

**Nephro-lithotomy.**—This operation is performed for the removal of stone from the kidney.

The kidney having been exposed and brought out at the wound, the presence and position of a stone can usually be determined by palpation between the finger and thumb, and to reach the stone an incision may be made in the kidney substance—*Nephrotomy* (first performed by Czerny), or the pelvis may be incised—*Pyelotomy* (first performed by Henry Morris).

If it is decided to incise the kidney substance, the renal vessels at the hilum are compressed by an assistant, and an incision is made in a line about half an inch behind the convex border. Zondeck has shown that an incision in this line divides fewer vessels than one made along the free border of the kidney. The incision is deepened until the renal pelvis is opened into, and the finger is then passed in to explore the interior of the pelvis and calyces. If a large branching calculus is found, a probe-pointed bistoury is used to enlarge the wound in the kidney, and the stone is removed. Before the wound in the kidney is closed, each of the calyces should



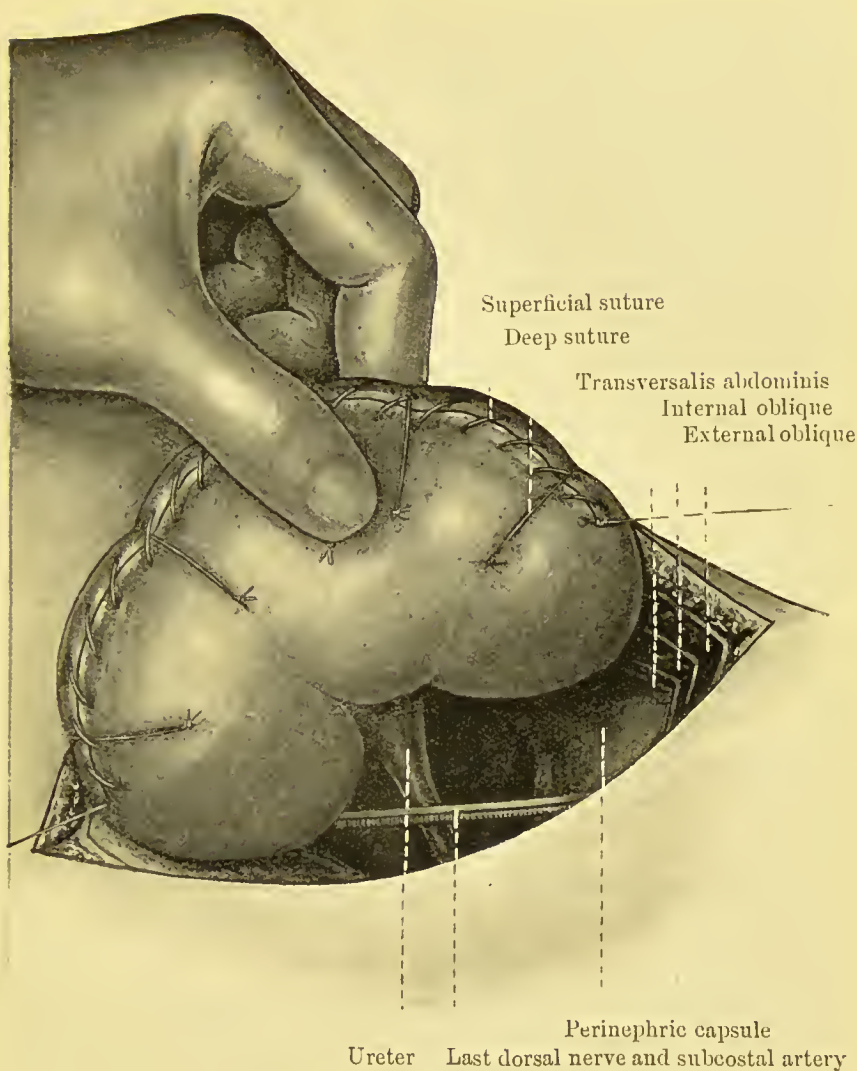


FIG. 214.—Suture of Right Kidney after Nephrotomy.

be examined with the finger, and a sound should be passed down the ureter to make sure that it is not obstructed.

If there is no evidence of an infective condition in the kidney, the wound in its substance is closed with series of deep and superficial sutures (Fig. 214).

If the kidney is infected, a drainage tube should be

introduced and secured in the pelvis. In any case, a drain should be left in the deeper part of the wound for a few days to guard against leakage of urine from the renal tissue. If the stone is located in the pelvis of the kidney, the incision may be made directly into the pelvis—*Pyelotomy*. This is attended with much less bleeding than nephrotomy, and the opening in the pelvis can be securely closed by two super-imposed tiers of sutures. The risk of leakage and of the establishment of a urinary fistula has been exaggerated.

**Nephrectomy.**—For the removal of the kidney, access may be obtained either from the loin or by way of the abdomen. The lumbar operation is that selected in cases of rupture of the kidney and in suppurative and tuberculous conditions; the trans-peritoneal route is preferred in the case of large tumours.

In the majority of cases, a diseased kidney is so intimately fused with surrounding structures by adhesions that the attempt to remove the organ intact in its capsule is both difficult and dangerous. Except in the case of malignant tumours, therefore, it is best to enucleate the kidney from its capsule.

*Lumbar Nephrectomy.*—The kidney is exposed through the usual lumbar incision, which may be extended downwards as far as is necessary to afford free access. The fatty capsule is separated sufficiently to expose the true capsule, in which a short incision is made to admit the fingers in order that the organ may be shelled out. When the kidney is being removed for malignant disease, an extra-capsular operation is performed, the fatty capsule and all adhesions being separated from the true capsule.

After the kidney has been freed all round, it is pulled out of the wound and the structures at the hilum are defined. If a long pedicle can be obtained, it is grasped between the fingers and thumb, and the renal artery and vein are isolated, ligated separately with stout catgut,

and divided. If the pedicle is too short to admit of this, the structures at the hilum must be ligated *en masse*, and after they have been divided and the kidney removed, the artery and vein are secured separately. The ureter, which lies posteriorly, is then isolated and separated from the vessels. In suppurative and tuberculous conditions, the utmost care must be taken that the contents of the pelvis and ureter do not infect the wound. In the majority of cases it is sufficient to tie the ureter and cut it across with the cautery. When it is thickened and infected with tuberculous disease, it should either be secured in a corner of the wound for subsequent injection with iodoform, or excised right down to its termination in the bladder.

*Trans-peritoneal Nephrectomy.* — With the patient in the dorsal position, the incision is made in or near the middle line of the abdomen. If more room is required, a lateral incision, in the line of the intercostal nerves, is added to it. The small intestines are packed away to the other side of the abdomen, and the parietal peritoneum is incised parallel with and along the outer side of the colon, and the colon stripped inwards towards the middle line. The parietal peritoneum is then retracted outwards, and all the vessels passing to the kidney are isolated and secured. The pedicle is much more easily dealt with by the trans-peritoneal than by the lumbar route. Difficulty may be met with in relation to extension of a tumour along the renal vein and adhesions to the surrounding parts, especially those beneath the vault of the diaphragm. On the left side, adhesion to the spleen may necessitate the sacrifice of part or the whole of this organ.

After the kidney has been removed, the raw surface is covered over by drawing together the edges of the peritoneum. A drainage tube should be brought out through an opening in the loin.

**Nephrostomy and Pyelostomy.**—In certain conditions

of the ureter and bladder, and especially when the entire bladder has to be removed on account of malignant disease, it is necessary to establish a permanent fistula in the loin.

The simplest method of establishing a urinary fistula is, after having exposed the kidney and upper part of the ureter by a lumbar incision, to divide the ureter and bring it out in the loin. The ureter is divided three or four inches below the kidney, and is fixed to the skin at the outer edge of the erector spinæ. Its orifice must be split transversely, and secured to the skin by sutures to prevent subsequent contraction. The distal end of the ureter is ligated and its mucous membrane cauterised. To prevent soiling of the clothing, an apparatus such as that designed by Watson of Boston must be worn; it consists of a cup-shaped rubber hemisphere, strapped to the loin by elastic straps, and connected with a receptacle for the collection of the urine.

It is not advisable to perform nephrostomy on the two sides simultaneously; an interval of a week or ten days should elapse between the two operations.

*Exposure of the Upper End of the Ureter.*—The upper or lumbo-renal portion of the ureter is exposed by the same incision as is employed for exposure of the kidney. It is frequently necessary, especially in stout subjects, to prolong the incision downwards and forwards. The kidney having been enucleated from its fatty capsule and brought out at the wound, is first drawn backwards to display the anterior surface of the ureter, and then towards the middle line to give access to the posterior surface (Fig. 215). The further procedure depends on the condition for which the operation is undertaken. If there is a stone impacted in the ureter, the wall is incised and the stone removed. A sound should then be passed along the ureter to make sure that it is patent, and that there is no stone farther down in its course.



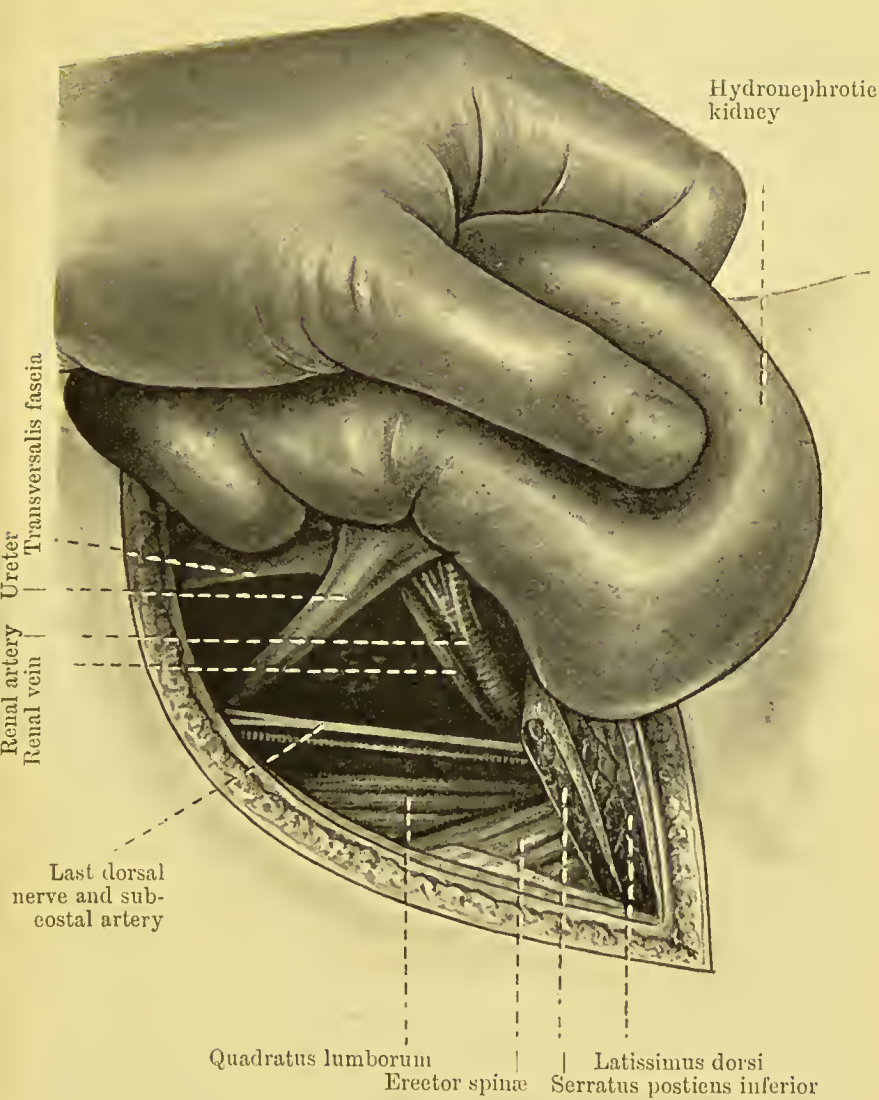


FIG. 215.—Exposure of Upper Part of Left Ureter.

If there is a valvular obstruction at the junction of the ureter with the pelvis, this is corrected after the fashion of a pyloroplasty, or by making an anastomosis between the ureter and the most dependent part of the pelvis.

Although wounds of the ureter can usually be efficiently



closed by sutures, it is advisable to provide for drainage of the external wound.

**Operations on the Abdomino-pelvic Portion of the Ureter.**—*Extra-peritoneal Method.*—The patient is placed on his back, and an incision is made in the line of the fibres of the external oblique, and in its lower part parallel with, and about three fingers' breadth above, Poupart's ligament. If the access is inadequate the incision should be continued upwards along the outer border of the rectus. The dissection is similar to that described for the common iliac artery. The three lateral abdominal muscles and the transversalis fascia are divided in the line of their fibres, and the peritoneum is stripped up from the fascia over the iliacus and psoas muscles. The ureter is lifted off the great vessels along with the peritoneum, and is easily recognised and isolated, especially if it is thickened by disease, such as tuberculosis, or is the seat of an impacted stone. When found it can be traced upwards on the posterior abdominal wall towards the kidney, and downwards beyond the bifurcation of the common iliac artery along the wall of the true pelvis as far as the bladder. If a stone is impacted in the pelvic portion, it should, if possible, be displaced upwards to a more accessible part to facilitate the stitching of the wound in the ureter. The opening in the ureter is closed with fine catgut or silk sutures.

*Trans-peritoneal Method.*—This method is to be preferred when access is required to the lowest four inches of the ureter. The patient is placed in the Trendelenburg position, and the abdomen is opened above the pubes in or near the middle line. The intestines are displaced upwards and packed off with gauze. In a thin person, the ureter is readily seen and felt through the peritoneum. When there is a deposit of fat behind the peritoneum, the ureter requires to be searched for, and is most readily found where it crosses the bifurcation of the common iliac

artery. The peritoneum is divided, the ureter exposed by dissection, and a silk thread thrown around it. It can then be readily traced either upwards or downwards as may be required. If a stone is found, it should be brought to the most accessible part of the ureter before laying the tube open and removing it.

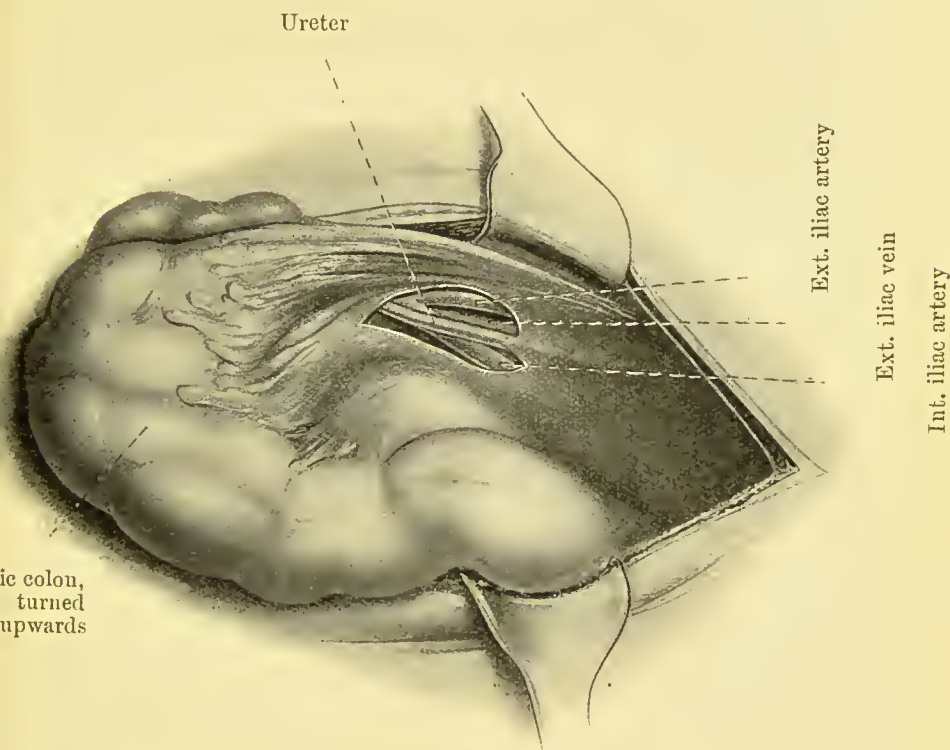


FIG. 216.—Exposure of Left Ureter by Trans-peritoneal Method.

*Access to the intra-vesical portion of the ureter* is obtained through the bladder. This viscus is opened above the pubes by an incision parallel with the brim of the pelvis, and the edges being held apart the floor of the bladder can be inspected and palpated. Should there be a stone impacted in the intra-mural portion, the mucous membrane is incised over it and the stone shelled out with a scoop or director. It is not necessary to stitch the incision thus made.

**Ureteral Anastomosis.**—When the ureter has been intentionally or accidentally divided in the course of an operation it is most efficiently re-united by the invagination method introduced by van Hook. As usually performed, the vesical end of the ureter is closed and a longitudinal slit is made lower down, into which the renal end of the ureter is inserted. The edges of the slit are then stitched with fine sutures all round to the wall of the portion implanted in it. This procedure may be carried out either by going through the peritoneum or extra-peritoneally.

**Implantation of the Divided Ureter into the Bladder.**—In resections of the bladder for tumour it is sometimes necessary to sacrifice the lower portion of one or other ureter. The upper end must then be inserted through a fresh opening into the bladder—*uretero-cysto-neostomy*. The union is usually effected end-to-side. The ureter is cut across obliquely; a small hole is made in the bladder and the ureter is pulled through this by means of a fine silk thread, the ends of which are passed through the bladder wall about half an inch distant from the opening and tied. The bladder is then stitched over the ureter as in a Witzel's gastrostomy. Some surgeons split the lower end of the ureter before fixing it to the wall of the bladder.

Another method of inserting the ureter into the bladder, is to pass a ureteral catheter through the urethra into the bladder and bring its end out through an incision in the bladder at the site of the anastomosis decided upon; the end of the catheter is inserted into the ureter and is fixed to it with a catgut ligature. If the catheter is now pulled upon, the end of the ureter is brought into the bladder and is fixed there by successive tiers of sutures. The ureteral catheter drains the ureter and holds it in position until union takes place.

**Implantation of the Ureters into the Intestine (Uretero-entero-anastomosis).**—When the bladder is imperfect from birth, as in extroversion, or when it has been removed completely for malignant disease, the urinary secretion may be diverted into the intestine. As first carried out by Maydl, the ureters were inserted into the pelvic colon. With the object, however, of diminishing the risk of an ascending infection from the bowel to the kidneys, the portion of intestine employed should be isolated by making an anastomosis between the two limbs of the loop employed. The loop of intestine is clamped as low down as possible before making the anastomosis.

In performing the operation for extroversion, the terminal portion of the ureters along with an elliptical portion of the wall of the bladder is dissected out in one piece so as to maintain their normal relationships, and this is inserted into a longitudinal incision made through one of the muscular bands of the pelvic colon.

## CHAPTER XXXVIII

### OPERATIONS ON THE BLADDER AND URETHRA

SUPRA-PUBIC CYSTOTOMY. SUPRA-PUBIC PROSTATECTOMY. CYSTECTOMY: *Partial; Complete.* PERINEAL CYSTOTOMY: *Perineal lithotomy; Perineal prostatectomy.* EXTERNAL URETHROTOMY.

### OPERATIONS ON THE BLADDER AND URETHRA

THE bladder may be opened above the pubes—*supra-pubic cystotomy*,—or from the perineum—*perineal cystotomy*.

**Supra-Pubic Cystotomy.**—When limited access will suffice, a median incision may be employed, but when manipulations are to be made within the bladder, for example, in the removal of a tumour or an enlarged prostate, the curved, horizontal incision of Kocher made in the interspinous line is to be preferred (Fig. 156). If necessary the operation can be performed under local anæsthesia. From eight to ten ounces of warm saline solution are introduced into the bladder by means of a catheter, and the patient is placed in a moderately high Trendelenburg position. By these means the bladder is projected towards the abdomen and the peritoneal reflection in front of it is raised. Some surgeons prefer to distend the bladder with air, as it interferes less with inspection of the interior. An incision through the skin and subcutaneous fat is made in the interspinous fold from



one internal ring to the other. In the fat are a few branches of the common femoral vessels on either side. The strong aponeurosis covering the recti is divided in the line of the skin wound. The recti muscles are then

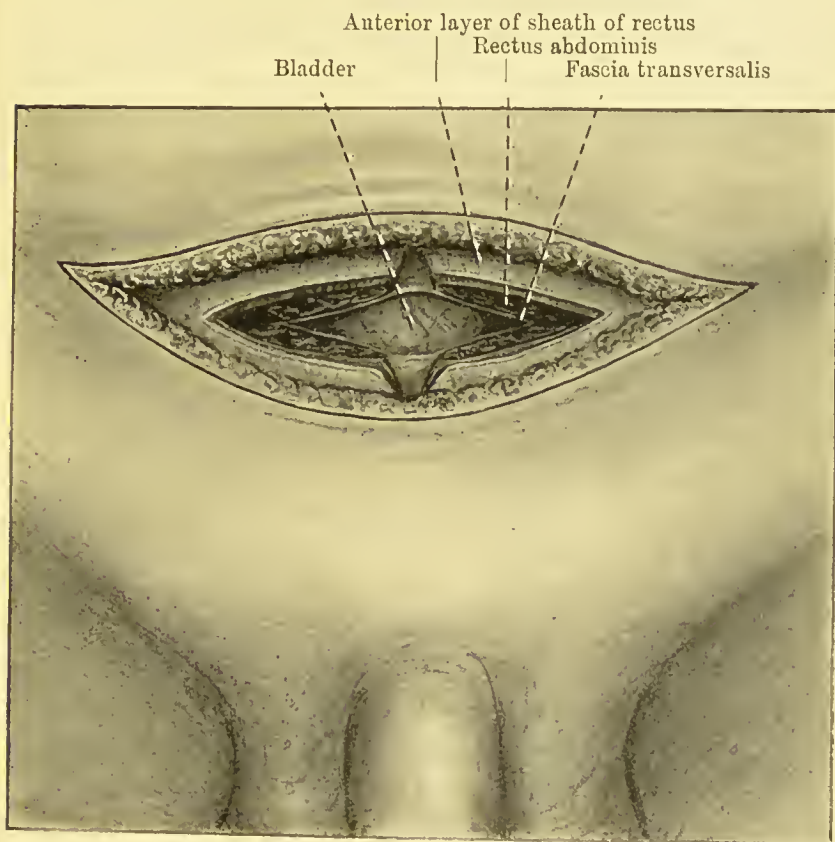


FIG. 217.—Supra-pubic Cystotomy.

separated in the middle line by blunt dissection and held asunder by retractors, or, if more access is required, they may be cut across about an inch above their pubic attachments. The finger is introduced behind the symphysis and draws upwards the extra-peritoneal fat and the reflection of the peritoneum, exposing the bluish-pink bladder wall. Two fixation sutures having been

inserted in the centre of the exposed portion of the bladder, a small vertical opening is made between them, and the finger is introduced before all the fluid is allowed to escape. The edges of the mucous membrane are caught with toothed forceps; and if it is found necessary to enlarge the opening, the mucosa, on account of its greater extensibility, does not require to be so freely divided as the muscular coat. When the manipulations within the bladder are completed, if there is neither infection nor hæmorrhage, the opening may be closed by means of a fine continuous suture introduced in two or more tiers, the first of which includes only the mucous membrane. Before the second layer of sutures is inserted, the wound should be irrigated with salt solution. A small glass drain is introduced into the space of Retzius through a separate opening, and the main wound is closed by successive tiers of suture. In adults, a soft rubber catheter should be fixed in the bladder and connected with a suction apparatus, but this is not necessary in boys, who have no difficulty in emptying the sutured bladder at natural intervals.

When there is pronounced infection or considerable oozing of blood, or if the bladder has been bruised in the course of the operation, the opening is not closed. A large glass tube, with lateral perforations but closed end, is passed down to the floor of the bladder, and inside this a catheter, size 16 to 18, is inserted and connected with a suction apparatus.

The wound in the aponeurosis and skin is stitched round the tube. In the course of two or three days the glass tube is removed and the rubber catheter alone retained until about the end of a fortnight, when the power of natural micturition usually returns.

When the supra-pubic opening is to be retained permanently—*supra-pubic cystostomy*—a No. 12 catheter is large enough, and is most efficiently secured in position

by means of an encircling silver ring provided with eyes, through which threads are connected and fixed to the skin with plaster. A satisfactory degree of continence is attained, and the patient may be able to pursue his occupation. The tube is provided with a stop-cock, and should be withdrawn and cleaned every day. Poncet, who has done much to establish supra-pubic cystostomy, stitches the edges of the bladder to the skin.

**Supra-Pubic Prostatectomy.**—This operation is associated with the name of P. J. Freyer. The bladder is opened as already described, and the condition of the prostate investigated. In determining the limits and disposition of the prostate and its relation to the prostatic urethra, we have found it helpful to introduce a metal catheter into the bladder. If enucleation is to be undertaken, the mucous membrane lying behind the commencement of the prostatic urethra is cut with a guarded knife, or torn through with the finger nail.

The enucleation is greatly facilitated if the prostate is pushed well forward from the rectum. This may be done by the operator inserting two fingers of his gloved right hand into the rectum, while he employs the left hand to enucleate; or an assistant may push forward the prostate. The separation is effected with the finger used as a blunt dissector, and the dissection is carried between the fibro-adenomatous nodules and the thin film of prostate which invests the capsule, until the mass is shelled out in one or in two or more portions. The prostatic urethra, which in the enlarged prostate is represented by a mere film of epithelium, is removed along with the gland.

During the enucleation a stream of hot water is passed into the bladder through the catheter in the urethra; and drainage is afterwards established by means of the arrangement of tubes already described. With a view to providing dependent drainage, Lynn Thomas pushes

a strong curved forceps from the bladder through the prostatic urethra until its point projects in the perineum, where it is cut down upon, and a drainage tube is seized between the blades and drawn back into the bladder. If, as happens in exceptional cases, the bleeding persists, in spite of irrigation with hot water, it may be necessary to have recourse to packing with gauze wrung out of adrenalin solution. We have known such hæmorrhage prove fatal.

**Cystectomy.**—Cystectomy, or excision of the bladder, is chiefly performed for new growths. It may be partial or total. Owing to the tendency to recurrence in malignant tumours, as well as the possibility of a change in the character of a benign growth, all tumours of the bladder should be subjected to a radical operation.

*Partial Cystectomy or Resection of the Bladder.*—Even after removal of as much as two-thirds or more of the bladder, the remaining portion is capable of adapting itself to form an efficient receptacle for the urine.

To afford sufficient access for the removal of extensive growths, it has been recommended to divide the symphysis or even to perform an osteo-plastic resection of the pubes. In women, simple division of the symphysis greatly improves the access.

With the patient in the high Trendelenburg position, Kocher's horizontal incision with division of the recti, and the use of good retractors, yields satisfactory access in the majority of cases. C. H. Mayo strongly recommends the transperitoneal method and makes a median incision.

The peritoneal cavity having been opened and the intestines packed off, the bladder is seized with two catch-forceps, lifted into the wound, and opened by a two-inch vertical incision. The fluid in the bladder is mopped up and the incision enlarged upwards and downwards until it is ample for the purpose in view.



The tumour is seized with catch-forceps and may be cut from the bladder with scissors, and the denuded area seared with the Paquelin cautery, or it may be resected with the cautery. No sutures are required to close the raw areas, cicatrization being quite sufficient, but if hæmorrhage continues it is better to close the gap with sutures. If one of the ureteral openings is involved, the ureter is divided near the bladder and drawn into the abdomen through a perforation in the peritoneum close to the remaining portion of the bladder, into which it is implanted and fixed with catgut sutures. The peritoneum is closed over the exposed ureter in a fold so as to ensure rapid healing.

If the bladder is free of infection, the wound in the anterior wall is closed by a through-and-through continuous mattress suture of catgut, and the line of suture is invaginated and protected by a peritoneal suture. As a rule the abdominal wound is closed without drainage. If the patient has any trouble in voiding the urine, a catheter is passed at regular intervals.

*Total Cystectomy or Excision of the Bladder.*—The most important point in connection with total excision of the bladder is the method of dealing with the ureters. The choice lies between implanting them in the lower part of the pelvic colon, or bringing them out in the lumbar region—lumbar nephrostomy (p. 506). Statistics show that implantation is attended with a much higher mortality than nephrostomy, and F. S. Watson, who has paid special attention to this question, recommends that lumbar nephrostomy should be performed from four to six weeks before the bladder is excised.

The abdomen is opened by a median incision, and the peritoneum covering the bladder is split in the sagittal plane from front to back in its whole extent and separated by blunt dissection as far as the entrance of the ureters. If they have not previously been transplanted, the ureters



are then ligated and divided. The urethra is cut across at the junction of its prostatic and membranous portions, and the bladder is then extirpated by blunt dissection. If the prostate and seminal vesicles are involved, they must also be removed. After the hæmorrhage has been arrested, the peritoneum is sutured and the abdominal wound closed—provision being made for drainage either supra-pubically or by the perineum.

**Perineal Cystotomy.**—The perineal route, which was formerly greatly favoured, has almost entirely been abandoned in favour of the supra-pubic. It is still sometimes selected for the removal of stone from the bladder (*perineal lithotomy*), and in excision of the prostate (*perineal prostatectomy*).

*Perineal Lithotomy.*—The incision may be made in the middle line of the perineum—*median cystotomy* or *lithotomy*, or it may be carried from the middle line backwards and outwards to one or other side—*lateral cystotomy* or *lithotomy*.

A grooved staff is passed along the urethra into the bladder and the membranous urethra is opened by cutting down upon the staff. The knife is then passed along the groove in the staff, dividing the prostatic urethra and floor of the bladder, after which the staff is withdrawn and the finger or lithotomy forceps introduced and the stone removed. A drainage tube is then passed into the bladder.

The median operation is to be preferred when the stone is impacted in or near the neck of the bladder.

*Perineal Prostatectomy.*—This method of dealing with the enlarged prostate is best adapted to those cases in which the prostate is hard and comparatively small, and in which, therefore, its removal would be difficult or impossible by the supra-pubic route. The perineal operation has been improved by F. S. Watson, H. H. Young, and Proust. The patient is placed in the lithotomy

position, and a curved incision is carried from one ischial tuberosity to the other, its convexity reaching forwards to the lower border of the pubic arch. After the skin and superficial fascia have been divided, the dissection is carried through the subcutaneous fat over the under surface of the levatores ani. The bulb of the urethra and the muscular fibres of the accelerator urinæ are exposed at the anterior part of the wound. The anterior fibres of the accelerator, and, deeper, the recto-urethralis muscle, are divided transversely and are then drawn forwards along with the transversus perinei muscles. By cutting transversely and more deeply towards the posterior surface of the bulb, the posterior fibres of the compressor urethræ muscle, which covers the under surface of the membranous urethra, are exposed. Above this muscle is the prostate, which is covered on its postero-inferior surface by a dense layer of connective tissue containing non-striated muscle. This layer must be drawn downwards and divided transversely in order to expose the smooth posterior surface of the prostate. To avoid injuring the rectum, which is one of the chief dangers in this operation, it should be drawn backwards. The adenomatous masses are removed by blunt dissection by the fingers, or the lateral lobes are dissected out with the aid of a cutting instrument, usually the scissors. The manipulations are rendered easier if the urethra is opened on a grooved staff and Young's prostatic retractor inserted, whereby the prostate is brought nearer the surface. Young has completely excised the prostate and seminal vesicles in cases of malignant disease.

**External Urethrotomy.**—This operation is called for in cases of stricture of the urethra, especially when this is complicated by peri-urethral cellulitis or fistula.

If the stricture is permeable, a Syme's staff is passed along the urethra until the shoulder of the instrument rests against the stricture. The patient is now placed

in the lithotomy position, and an incision is made in the middle line of the perineum, dividing the urethra and exposing the shoulder of the staff; the stricture is then divided by pushing the knife along the groove in the staff.

If the stricture is impermeable, a Wheelhouse's staff is passed down the urethra until it is arrested, and the bulbous end of the instrument is cut down upon and the urethra opened in front of the stricture. The edges of the incision in the urethra being held aside, the lumen of the stricture is sought for with the help of a probe or a Teale's director. The stricture is then divided. A rubber catheter is inserted from the meatus of the urethra into the bladder and is connected with a suction apparatus. If septic infection is present, a drain is inserted into the perineal wound, which is left open, but in the absence of sepsis the tissues divided in the perineum are brought together with successive tiers of catgut sutures.

In cases of short annular stricture, the stenosed portion of the urethra may be resected and the cut ends of the urethra united to one another over a catheter.

## CHAPTER XXXIX

### OPERATIONS ON THE MALE GENITAL ORGANS

TESTIS AND EPIDIDYMIS: *Orchidectomy; Epididymectomy; Excision of Seminal Vesicles.* OPERATION FOR ECTOPIA TESTIS: *Orchidopexy.* VAS DEFERENS: *Vasectomy; Vasorrhaphy; Vasodidymostomy.* OPERATION FOR VARICOCELE. OPERATIONS FOR HYDROCELE. CIRCUMCISION. AMPUTATION OF PENIS: *Partial; Complete.*

**Removal of the Testis.—Castration or Orchidectomy.**—If the skin of the scrotum is not involved in the disease, the incision is made in the line of the inguinal canal, about a finger's breadth above the inner portion of Poupart's ligament, exposing the aponeurosis of the external oblique and the external abdominal ring. The coverings of the cord—intercolumnar fascia, cremaster, and infundibuliform fascia—are divided, and the spermatic cord exposed. The testis enclosed in the tunica vaginalis is pulled out of the scrotum, and the vas deferens separated from the other constituents of the cord and divided, the vessels secured with forceps and tied separately, and the testis removed. If the cord is invaded by the disease, the inguinal canal is opened up by splitting the aponeurosis of the external oblique, and the constituents secured at the internal abdominal ring. The canal is then repaired and the external ring closed. If it is considered advisable to drain the wound, the tube should be inserted through a small opening made at the lowest part of the scrotum.

When the scrotum is involved, and particularly when there are sinuses, or a fungus testis, the affected portion must be included between semilunar incisions, and the ellipse of skin removed along with the testis.

When the operation is performed for malignant disease, the incision should be extended sufficiently to admit of the lymphatics and inguinal glands being removed along with the testis in one piece, on the same principle as in removing the breast and axillary contents for cancer.

**Epididymectomy.**—When tuberculous disease is strictly confined to the epididymis, and particularly when the other testis has already been removed, excision of the epididymis alone is indicated. The cord is exposed through an inguinal incision, and the testis withdrawn through the wound and examined. If it is found that the disease is confined to the epididymis, the reflection of the tunica vaginalis at the lower pole of the globus minor is snipped through with scissors, and the epididymis is separated from the back of the body of the testis. When the globus major is reached, the vas is separated from its accompanying vessels and cut across just above the upper border of the testis. The reflection of the tunica vaginalis on to the globus major is then divided with scissors, and the separation of the epididymis from the testis is completed. The vessels supplying the testis, which enter the gland at its upper and inner aspect, are carefully preserved. To make certain that there is no disease in the body of the testis, an incision should be made along its posterior aspect. If a limited focus is discovered, it may be excised, but if the disease is extensive, the gland must be removed.

If the testis is to be conserved, the end of the divided vas deferens is implanted in the parenchyma, and the tunica albuginea sutured along the posterior surface. The testis is then replaced in the scrotum, and a small



puncture made at the lowest part of the sac for the passage of a drainage tube.

**Excision of the Seminal Vesicle.**—In cases of tuberculosis in which the disease has spread to the vas deferens and the seminal vesicle, these structures should be removed as well as the testis.

The vas can be exposed as far as the internal abdominal ring by opening up the inguinal canal; and by enlarging the internal ring outwards, it can be traced to the base of the bladder. The seminal vesicle is best reached from the perineum through a curved incision in front of the rectum, similar to that employed in perineal prostatectomy.

**Operation for Ectopia Testis. — Orchidopexy.** — An incision is made in the line of the inguinal canal about a finger's breadth above Poupart's ligament, exposing the external abdominal ring. The aponeurosis of the external oblique is slit up, and the testis exposed as it lies in the canal. The coverings of the cord are freely divided, and the relations of the testis to the processus vaginalis determined. It is usually found that after the processus has been freely divided the testis can be brought down to the bottom of the scrotum. If this is not possible, the vas deferens with its accompanying artery must be separated from the other constituents of the cord and held aside. The remaining vessels are then divided and ligated. With the finger, a bed for the testis is made in the scrotum. A chromic gut suture is now passed through the lower pole of the testis, including the tunica albuginea, and the two ends of the suture are brought out through the lowest part of the scrotum about a quarter of an inch apart, and tied over a small piece of rubber tubing to avoid strangulation of the intervening portion of skin. To prevent retraction of the testis and the scrotal wall to which it has been attached, the sutures may be passed through the skin of the inner

aspect of the thigh, and the limb kept extended by a simple wooden splint, or the cord may be stitched to the margin of the external abdominal ring. Lanz fixes the threads which have been brought out through the scrotum to the thigh with adhesive plaster. We have found these procedures unnecessary if the testis has been sufficiently mobilised.

If, as is frequently the case, the condition is complicated by the presence of a hernia, the radical operation for the cure of the hernia should be performed before the wound is closed.

**Vasectomy.**—This simple operation was formerly recommended for enlarged prostate. It is performed under local anæsthesia. The cord is grasped through the skin between the finger and thumb, the vas defined, and a small incision made down upon the cord. The vas is withdrawn, an inch or two resected, and the ends allowed to slip back into the wound, which is then sutured.

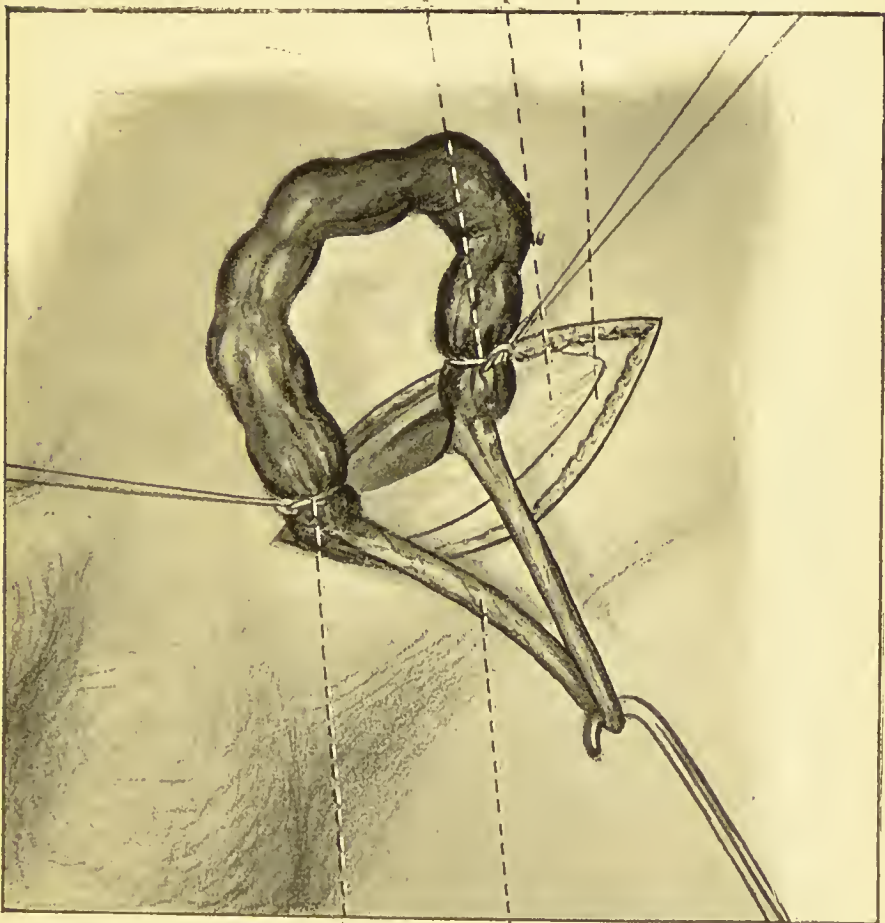
**Vasorrhaphy.**—An operation for uniting the vas deferens when it has been accidentally divided, say in the course of an operation for hernia, has been devised by the brothers Mayo. The ends of the divided vas having been isolated, a straight, round sewing needle is inserted, eye first, into the lumen of one end, and the point is then introduced into the lumen of the other end. After the point has passed for a distance of an inch and a half along the lumen, it is made to transfix the wall and protrude through it. The needle now acting as a temporary splint, the two ends of the vas are approximated to one another, and united by a series of fine chromic gut sutures passed round the circumference of the junction. A piece of connective tissue from the adjacent cord is stitched over these sutures to strengthen the union. The needle having served its purpose as a splint is then withdrawn.

**Vaso-didymostomy.**—In cases of occlusion of the vas by

cicatricial contraction following gonorrhœal epididymitis, and after partial resection of the epididymis and vas, attempts have been made to re-establish the function of

Ligature applied just above testis

Aponeurosis of external oblique  
Fascia of Scarpa



Ligature applied at external ring

Vas deferens isolated and held aside

FIG. 218.—Operation for Varicocele.

the tube by implanting the distal end of the divided vas in the parenchyma of the testis.

**Operation for Varicocele** (Fig. 218).—The cord is exposed as it emerges from the external abdominal ring, by an in-

cision a finger's breadth above and parallel with the inner third of Poupart's ligament. The veins divided in the superficial fascia are usually larger than normal and should be securely ligated. After its coverings have been divided longitudinally, the cord is hooked up with the finger and pulled upon until the testis appears in the wound. The vas deferens with its accompanying vessels, which lie on the posterior aspect of the cord, are then isolated and held aside with a strand of gauze or a blunt hook. The dilated veins of the pampiniform plexus are now defined at the external abdominal ring where they form several large trunks, and these are traced downwards as far as the upper pole of the testis, where they constitute a freely anastomosing plexus. The upper end of the bunch of veins thus isolated is secured by forceps at the external abdominal ring, and the lower end just above the epididymis. The intermediate portion having been removed, each bunch of veins is securely ligated by means of a Staffordshire knot. The ligatures are left long and are tied to one another, so that the ends of the divided veins are brought together, and the testis is suspended at a higher level in the scrotum. The vas and the vessels accompanying it, now relatively much longer than the stump of the divided veins, are packed back into position and the wound is closed without drainage. Only when the skin of the scrotum is exceptionally lax is it necessary to remove an elliptical portion of it.

**Operation for Hydrocele.**—We have found the procedure recommended by Winklemann the most satisfactory operation for hydrocele. The cord is exposed at the external abdominal ring by an incision similar to that made for castration, and after its coverings have been divided, it is pulled upon until the upper end of the distended tunica vaginalis appears in the wound. The coverings of the cord are slit open until the tunica vaginalis is clearly exposed. The tense wall of the



hydrocele is then picked up with two pairs of Kocher's artery forceps, and a puncture is made between them, either with a knife or with a trocar and cannula. As the fluid escapes, the forceps are pulled upon and the collapsed sac, together with the testis, is withdrawn from the

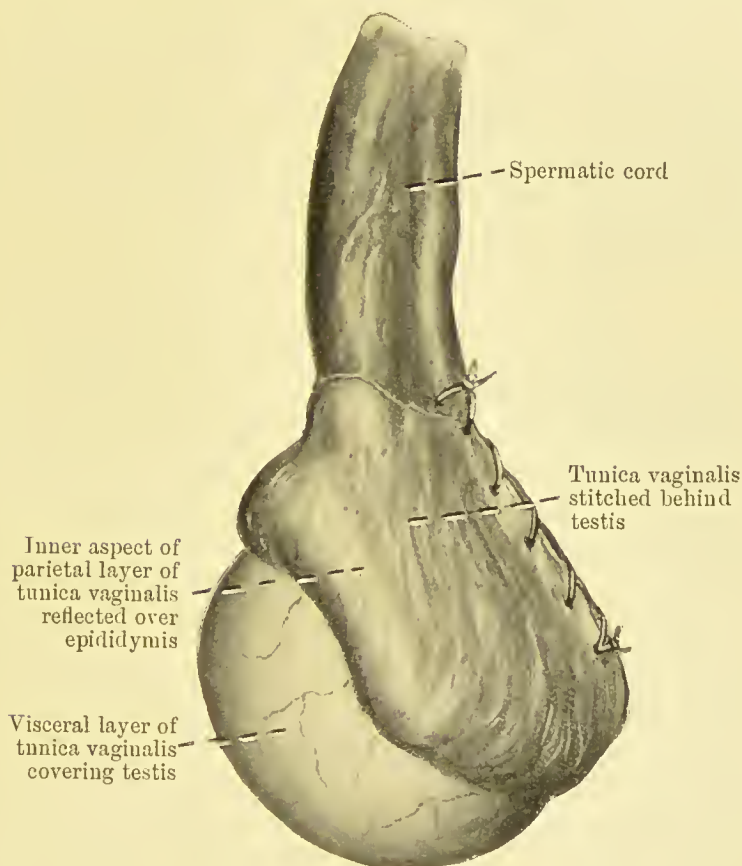


FIG. 219.—Winklemann's Operation for Hydrocele.

scrotum. The parietal layer of the tunica vaginalis is then slit longitudinally from end to end, the two halves folded back till they meet behind the epididymis and the cord, and the cut edges united in this position by a continuous catgut suture (Fig. 219). In this way the tunica vaginalis is turned inside out. All bleeding points



are then secured with ligatures, and the testis returned to the scrotum. A small drainage tube is introduced through a puncture made for the purpose at the bottom of the scrotum, the inguinal incision completely closed, and firm pressure exerted on the scrotum by means of wool and a bandage.

When the parietal layer of the tunica vaginalis is exceptionally thick and bulky, a portion, or the whole of it, may be cut away with scissors. This necessitates ligation of a great many bleeding points, and is liable to be followed by reactionary hæmorrhage, however carefully the vessels are secured.

## OPERATIONS ON THE PENIS

### **Circumcision for Phimosi*s*.**—*Slitting the Prepuce.*—

When the prepuce is narrow, but the prepuce not abnormally long or redundant, it is usually sufficient to slit the skin longitudinally along the dorsum. A broad flat director is inserted between the prepuce and the glans, care being taken that it is not introduced into the urethra, and one blade of a pair of probe-pointed scissors, such as Mayo's, passed along the director. The incision should extend a short distance beyond the level of the corona. The lining membrane of the prepuce is usually redundant, and the excess must be clipped away. A continuous suture of fine catgut is then introduced to bring together the two layers of the prepuce, after which a suitable dressing is applied.

*Removal of the Prepuce.*—When the prepuce is abnormally long, the redundant portion must be removed. If possible all adhesions between the lining membrane of the prepuce and the glans should be separated by retracting the prepuce as far as the corona. The prepuce is then pulled forward again, grasped in front of the glans with a pair of dressing forceps applied to it

obliquely from above downwards and forwards, and the portion in front of the blades of the forceps is cut off with a long bistoury. Care must be taken to remove just enough skin to enable the glans to be completely exposed, and yet to leave a covering for the sensitive papillæ of the corona. After the forceps are removed, the lining membrane of the prepuce, which still covers the glans, is slit up along the dorsum, and the excess cut away with scissors. The bleeding is arrested by torsion, or with fine catgut ligatures, special attention being paid to the vessels in the vicinity of the frenum. The cut edges of the outer and inner layers of the prepuce are then stitched together with fine catgut sutures.

**Amputation of Penis.—Partial Amputation.**—A piece of rubber tubing is applied round the base of the penis to prevent hæmorrhage, and a straight bougie passed down the urethra as far as the tourniquet. A short flap of skin and subcutaneous tissue is then raised from the ventral aspect, well behind the cancer, exposing the corpus spongiosum, which, together with the urethra, is divided by cutting down upon the bougie three-quarters of an inch in front of the base of the flap. A flap of skin, sufficiently long to cover the end of the stump, is then reflected from the dorsal and lateral aspects of the penis, and the corpora cavernosa divided by a circular incision at the level of the base of the skin flap. The tourniquet having been removed and the bleeding arrested, a small opening is made in the dorsal flap opposite the level of the urethra, the end of which is slit up laterally for a short distance, pulled through this opening, and stitched to its edges. Finally the dorsal and ventral flaps are united by horse-hair sutures.

**Complete Amputation.**—With the patient in the lithotomy position and a metal bougie in the urethra, a

mesial incision is carried from the peno-scrotal junction to the mid-point of the perineum, splitting the scrotum and exposing the corpus spongiosum at the bulb. The corpus spongiosum is then cut across, the urethra dissected free of the corpora cavernosa as far back as the triangular ligament, and cut across just beyond the bulb. The crura are then traced backwards as far as their attachments to the rami of the pubes, and dissected off the bone. The structures on the dorsum

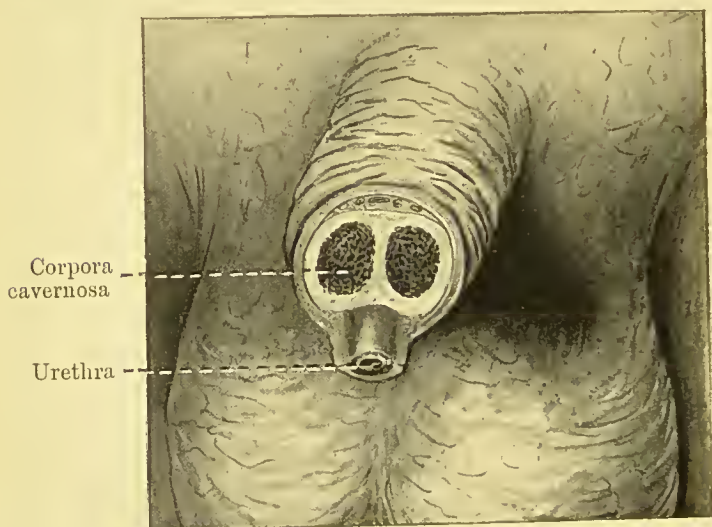


FIG. 220.—Partial Amputation of Penis.

are next divided by carrying an elliptical incision up to the symphysis, dividing the suspensory ligament, and the dorsal vessels as they pierce the triangular ligament.

The penis having been removed, the stump of the urethra is fixed to the edges of the perineal wound, about an inch in front of the anus, after which the two halves of the scrotum, containing the testes, are replaced and the skin sutured with horse-hair stitches.

To ensure complete removal of the lymphatic connections, the glands in front of the pubis, those accom-

panying the cord in the inguinal canal, and the deeply placed glands on the inner side of the femoral vein must be dissected out on both sides. This may be done at the same time as the penis is amputated, or, as Butlin recommended, as a secondary operation.

## CHAPTER XL

### ANÆSTHETICS<sup>1</sup>

GENERAL ANÆSTHESIA. *Preparation of patient; Prevention of Shock—Chloroform—Ether: Open method; closed method. Mixtures of Chloroform and Ether—Nitrous Oxide Gas—Ethyl Chloride—Preliminary Hypodermic Medication—Intravenous general Anæsthesia—The choice of an Anæsthetic—Dangers arising during Anæsthesia—Delayed Chloroform poisoning.*

LOCAL ANÆSTHESIA. *Infiltration Anæsthesia; Regional Anæsthesia; Spinal Anæsthesia; Freezing with Ethyl Chloride.*

THE term “anæsthesia” was suggested by Oliver Wendell Holmes when, in 1846, Morton first demonstrated that the inhalation of ether abolished consciousness and the sensation of pain.

#### GENERAL ANÆSTHESIA

The general anæsthetics most frequently employed for prolonged operations are chloroform, ether, and certain mixtures of these. For brief operations, inhalations of nitrous oxide, chloride of ethyl, or a combination of these, are commonly employed.

**Preparation of the Patient for the Administration.**—Except in cases of emergency, the patient should be prepared for the anæsthetic by having his diet and general mode of living regulated for a few days. When it is possible, he should be kept at rest in a hospital or

<sup>1</sup> We are indebted to Dr. J. Stuart Ross, Instructor in Anæsthetics, Royal Infirmary, Edinburgh, for again revising this chapter.



nursing home for two or three days, although not confined to bed during the whole of this period. A purgative should be administered about thirty-six hours before the operation, and the lower bowel cleared by an enema some hours before its actual performance. No heavy food should be given within twenty-four hours, but the patient should have a cup of beef-tea or clear soup three or four hours before. Milk is unsuitable for this purpose, as the semi-solid curd, if vomited while the patient is anæsthetic, may be drawn into the larynx, with serious consequences. Starvation as a preliminary to operation is often overdone, particularly in delicate patients. If very feeble or collapsed, the patient should have a pint of saline solution containing an ounce of brandy by the rectum, half an hour before operation; and atropin sulphate, gr.  $\frac{1}{120}$ , may be given hypodermically. In cases of intestinal obstruction or of gastric dilatation attended with copious vomiting of highly infective material, the stomach should be washed out before the anæsthetic is given.

Unless the patient is exceptionally nervous, he should be placed upon the operating table before the administration is begun, and should be allowed to lie in the position in which he feels most comfortable. The head and shoulders should be slightly raised, particularly in stout persons, care being taken that the neck is neither flexed nor extended unduly. As a precaution, the mouth should be inspected, to ensure that all artificial dentures have been removed, and to locate any loose or broken tooth which might be prised out by the gag, should it be necessary to use that instrument.

As soon as consciousness is lost, the shoulders may be lowered to the horizontal, the same care being taken as before regarding the position of the neck. When the muscles begin to relax, the head should be turned to one side, and a pillow placed under the opposite

shoulder, to permit of any mucus that may be secreted flowing easily out of the mouth. Should it be necessary during the operation to turn the head to the opposite side, the inside of the dependent cheek should first be sponged out, lest a pool of mucus may have gathered there. The two commonest difficulties during anæsthesia are clenching of the teeth and sagging back of the base of the tongue over the epiglottis. Both are best prevented by introducing a small dental prop between the teeth, either before starting the administration or shortly afterwards. The jaw (with the base of the tongue) can then easily be kept forward by pressing the fingers into the depression below the symphysis menti, and hooking it forwards. If the prop is used, resort to a mouth-gag or tongue forceps will rarely be called for.

**Prevention of Shock.**—The pathology of shock has been already explained (vol. i. p. 260), but the following points may be remembered in connection with shock under anæsthetics. No general anæsthetic can entirely shield the brain from centripetal impulses which cause shock, but keeping a level anæsthesia of moderate degree will minimise it. Too light a degree favours its occurrence, while too deep a level of anæsthesia in itself lowers blood pressure, particularly in the case of chloroform, and if shock be added to slight overdosage, a fatal result is not unlikely. Exaggerated or impeded breathing also causes shock, hence the necessity for its avoidance. The administration of *oxygen* from a cylinder is of assistance in cases where shock is feared. It may be led into the mouth through a small tube which passes under or through the mask.

**Chloroform.**—The anæsthetic properties of this drug were discovered by James Young Simpson in 1847. It may be prepared either from acetone, from pure ethyl alcohol, or from methylated spirit. We have found that prepared from methylated spirit as good in every way

as that from ethyl alcohol, and it is considerably cheaper.

In the administration of chloroform, the aim of the anaesthetist should be to present to the patient an atmosphere containing a gradually increasing vapour-strength of chloroform, until 2, or at most 3, per cent. is reached. With this, full narcosis can be produced in six or seven minutes. A steady level of anaesthesia can then be maintained by the use of 1 to  $1\frac{1}{2}$  per cent. To enable this to be done with scientific accuracy, special instruments have been devised, of which the best known is the Vernon Harcourt regulating inhaler. The use of such apparatus, however, presents many drawbacks, and the student is recommended to learn to anaesthetise by simpler methods. A Schimmelbusch frame is covered with four layers of domette or a layer of lint, and held over the face in such a manner that at least two-thirds of its circumference is kept half an inch from the skin, while the other third rests on the bridge of the nose. The chloroform is dropped on the lint—a few drops at first, later from 30 to 40 drops may be added every half-minute—until full narcosis is obtained. After that, considerably less will maintain anaesthesia. The golden rule is to see that the respirations are free and regular. If the patient struggles and holds his breath, the mask must be withdrawn until one inspiration of pure air has been taken. Struggling and breath-holding cause a great strain on the heart muscle, and impair its nutrition by partly arresting the circulation in the coronary arteries, and if, while it is in this condition, blood heavily charged with chloroform reaches the heart, it is very liable to be arrested by “relative overdose”—a form of syncope arising from which recovery is exceptional.

The signs of full anaesthesia are: quiet, “automatic” respirations, feeble conjunctival reflex, small pupils

which are insensitive to light, and complete museular relaxation. Rigidity of the museles is prolonged by the slightest element of asphyxia; to obtain relaxation, particularly of the abdominal museles, it is just as important to ensure a free airway as to give a sufficiency of chloroform. The signs of overdosage are: widely dilated pupils, weak, sighing respirations, and a grey pallor of the face and lips.

**Ether.**—There are two methods of administering ether—the open and the closed methods.

In the *open method*, a mask such as Bellamy Gardner's, which is so shaped as accurately to fit the face, should be used, and should be covered with twelve to sixteen layers of gauze if ether is to be used from the start; while if anæsthesia be induced by ehloroform, not more than eight or ten layers are permissible, otherwise syncope may be indued at the moment of change. A roll of gauze is placed on the face, encireling the mouth and nose, and on this the mask rests. This method ensures that respiration will take place through, and not around, the gauze upon the mask. This elose adaptation, which is highly desirable in the ease of ether, is eertainly dangerous in the case of chloroform, and it must be understood that if ehloroform is used as the inducing agent, it must be given *on a separate mask*, and in the manner above described. The ether is dropped on to the gauze, from 30 to 90 drops per minute being necessary for the maintenance of anæsthesia. Induction by this method is slow, and in strong or in alcoholic patients, impossible without the preliminary use of hypodermic medication (p. 539), but in most patients anæsthesia can readily be maintained by the open method after the induction stage has been passed.

*The Closed Method.*—This involves the use of a special inhaler. In Clover's original instrument the airways are too narrow; Hewitt's wide-bore apparatus will be



found more satisfactory. It consists of (1) a face-piece with a pneumatic pad, (2) an ether chamber, (3) a rubber bag of about one gallon capacity. An ounce and a half of ether is placed in the chamber, and the indicator set at zero. If the ether is not to be preceded by nitrous oxide gas or ethyl chloride, it is best to begin without the bag. The face-piece having been adapted to the face, the indicator is moved successively over to  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$ , and full ether, the last being reached in about one minute. The indicator is then pushed back to  $\frac{1}{4}$ , and the bag slipped on, care being taken to catch in it several expirations. During the rest of the induction the indicator is again moved slowly over to full ether, and anæsthesia is usually complete in about four minutes. After this stage is reached, the patient is allowed one breath of fresh air out of five, the ensuing expiration being caught in the bag; the indicator can be moved back to about  $\frac{1}{2}$  after the first few minutes.

The signs of anæsthesia are the same as when chloroform is used, but the respirations are fuller, and the pupil is not so small. Ether may without danger be pushed to the stage of dilatation of the pupil, and this is often necessary to obtain full muscular relaxation.

The closed method leads to a certain amount of urgency and labouring of the respiration, and to severe after-headache, in prolonged administration. It is therefore not so much used as formerly in major surgery, but its rapidity of induction and its great safety make it still valuable for brief administrations.

The administration of ether is sometimes preceded by that of a small dose of ethyl chloride, or of two gallons of nitrous oxide gas. Either of these hastens and facilitates the induction: the former is the easier to give, but the latter is the more pleasant for the patient, and has a long and deserved reputation for extreme safety.



**Mixtures of Chloroform and Ether.**—These are sometimes preferable, the best consisting of one part of chloroform and two parts of ether, and known as the C.E. mixture. That known as the A.C.E. mixture consists of one part absolute alcohol, two parts chloroform, and three parts ether. Schäfer and Scharlieb have shown that alcohol has the property of reducing the fall of blood pressure caused by chloroform, while ether has no such action. They recommend one part of alcohol to nine parts of chloroform. Mixtures are given in the same manner as pure chloroform, with this reservation, that the smaller the percentage of chloroform in the mixture, the closer may the mask be adapted to the face. The type of anæsthesia is that of chloroform, but the respirations are deeper, and the colour is better.

**Nitrous Oxide Gas.**—The administration of this valuable and safe anæsthetic can only be learned by attendance at demonstrations where the complicated apparatus can be seen and examined. The signs of anæsthesia are: moderate cyanosis, stertorous breathing, fixed eyeballs, and muscular relaxation. If the administration is pushed beyond this stage, jactitations begin, which are asphyxial in origin.

**Ethyl Chloride.**—This drug, employed as a general anæsthetic, was introduced some years ago as a substitute for gas. Its advocates claimed for it that it was easier to give and produced a longer period of anæsthesia from a single dose (90 seconds, as against 30 seconds with gas). Experience has shown, however, that it is by no means devoid of danger, and in many schools its use has been abandoned. When given alone, the dose varies from 3 to 5 c.c., according to the age of the patient, and it is given in a one-gallon bag, connected to a face-piece. It produces no cyanosis, and the respirations are quieter than with gas.

Guy of Edinburgh gives it with the admixture of one gallon of gas, in a special inhaler which is easily managed. The patient is made to take five breaths of the gas, and the ethyl chloride is then allowed to run into the bag from a tube previously charged and connected up; 3 c.c. is the maximum dose required, sometimes less suffices. The breath is usually held for a few seconds at this stage, but from the time free respiration is started, the patient is under in 25 seconds. The working period of anæsthesia lasts at least 90 seconds. This method has given excellent results, and has never caused the slightest anxiety in 30,000 cases at the Edinburgh Dental Hospital.

**Preliminary Hypodermic Medication.**—With a view of calming the patient before operation, and also of limiting the amount of volatile anæsthetic used, narcotics may be given hypodermically an hour or so before operation. The most usual are: *Morphin sulphate* (gr.  $\frac{1}{6}$ ), *with atropin sulphate* (gr.  $\frac{1}{120}$ ), or *with scopolomin* (gr.  $\frac{1}{120}$ ), *omnupon* (gr.  $\frac{1}{3}$  to gr.  $\frac{2}{3}$ ), *heroin hydrochlorate* (gr.  $\frac{1}{12}$  to gr.  $\frac{1}{6}$ ). Any of the above will reduce the amount of mucus secreted, and render the recovery from the anæsthetic more agreeable, as there is usually less after-vomiting. *Atropin* by itself secures both these objects, and does not depress the respiratory centre.

**Intravenous General Anæsthesia.**—Burekhardt has introduced a method of giving ether by intravenous infusion. A 5 per cent. solution in normal saline is prepared, and kept at a temperature of not less than 100° F. in a large vessel connected by a tube with a vein cannula. The median basilic vein is exposed under local anæsthesia, the cannula inserted, and about 8 oz. of the solution allowed to run in; anæsthesia is thus established in about 5 minutes. From time to time, as signs of recovery are observed, more of the solution is run in. The danger of the method lies in

the liability to clotting around the cannula. This may be guarded against by Kummel's modification, which consists in the use of a two-way stop-cock connecting the tube with a second receptacle, in which pure saline without ether, is kept at the same temperature. During the intervals when no more ether is required, normal saline can thus be allowed to dribble slowly into the vein. This undoubtedly reduces the chance of clot-formation. The method may be used in head cases, instead of the usual Junker's inhaler.

**The Choice of an Anæsthetic.**—So much depends on the preference of the individual surgeon, the custom and traditions of different schools and hospitals, and the personal experience and capacity of the administrator, that no rigid rules can be laid down regarding the choice of an anæsthetic. In general, it may be said that the following points require to be taken into consideration: the age and condition of the patient, the nature and probable duration of the operation, and the position of the patient during its performance. Chloroform and ether (C.E. mixture) is as a rule suitable for children under five, and for adults over sixty. In vigorous adults from eighteen to forty-five, the induction should be carried out with some other anæsthetic than chloroform, as experience has shown that it is in such subjects that sudden and fatal syncope is apt to occur. By patients suffering from valvular heart disease, if the compensation is good, chloroform is usually taken well, but if there is weakness of the heart muscle, C.E. mixture is to be preferred. In renal disease, also, chloroform or C.E. mixture is better than ether. When bronchitis is present, and in cases of empyema, chloroform, given very guardedly, is the only permissible anæsthetic. For excision of the tongue or jaw, the use of the Junker chloroform inhaler, by which a stream of chloroform vapour is pumped into the mouth or nose,

is advantageous. In brain surgery, ether causes too much congestion of the meninges, and chloroform should be given.

Ether is the most appropriate anæsthetic for conditions in which much shock may occur, and in which a very deep anæsthesia is required, such as castration, operations on the rectum, and the reduction of dislocations. In operations for goitre, ether given by the open method, preceded by a small dose of morphin or omnopon, is safest (p. 536). For operations requiring the vertical position, as in dental cases, the patient should on no account have chloroform. With any anæsthetic there is an element of risk in operations on the tonsils and adenoids, as many of the patients are the subjects of the condition known as the status lymphaticus. Guy's ethyl chloride and gas method has given good results; many use ethyl chloride alone, while others prefer C.E. mixture. In children over five, open ether is in our opinion safer than anything else.

**Dangers arising during Anæsthesia.**—The dangers arising during the administration of an anæsthetic are due either to depression or failure of the circulation, or to embarrassment of the respiration. Frequently these conditions coexist, but it is convenient to consider them separately.

*Circulatory depression or failure* (syncope) is most common under chloroform, but does occur under ether. Chloroform syncope may be divided into: (1) Primary syncope, from fear of the anæsthetic—the chloroform acting merely as the "last straw." (2) Syncope from "relative overdose," in which the heart is already embarrassed by obstructed breathing, and blood containing a large dose of chloroform reaches it as soon as the respiration is re-established. (3) Syncope from pure overdose, in which the medullary centres are gradually poisoned. (4) Reflex syncope, the afferent



impulse reaching the centres either by the vagus (during the induction period), or from the sensory nerves of the seat of operation. Though this form is more likely to occur if the operation is begun before full anæsthesia has been obtained, it may occur at any time; it is very sudden in its appearance, but fortunately, if promptly dealt with, is frequently recovered from. (5) Syncope from raising the head during anæsthesia. (6) Vomiting causes a certain amount of faintness, but rarely occurs during full anæsthesia. The most prominent *symptoms* are: pallor, more or less sudden in appearance, rapid failure of the pulse and respiration, and wide dilatation of the pupils. In the syncope from relative overdose, which occurs during the early stages, the onset is extremely rapid, and the condition frequently proves fatal. Syncope coming on later in the administration appears more gradually, and treatment is more often successful.

*Respiratory difficulty* may be due to an overdose of the anæsthetic, and is then associated with circulatory depression. It may also be due to mechanical obstruction of the airway, for example, (1) falling back of the tongue, (2) spasm of the muscles of the jaw and neck, (3) laryngeal spasm, (4) if the preceding are allowed to continue, a condition of general spasm of all the muscles of respiration may develop, which is only remediable by forcible inflation of the lungs through a tracheotomy wound.

The characteristic symptoms are: increasing stertor or cessation of breathing, duskiness of the lips, ears, and face, increasing to cyanosis. If the condition is allowed to continue, pallor supervenes, the heart failing secondarily; but timely treatment is almost invariably successful.

*Treatment.* — Patients suffering from either of the above conditions may be divided clinically into those who become *pale*, and those who become *cyanosed*.



The earliest threatening of *pallor* may be remedied by brisk rubbing of the lips with a rough towel, but in severe cases no time should be lost before lowering the head (children may easily be entirely inverted), pulling out the tongue with forceps, and starting artificial respiration by Sylvester's method. This should be done at the normal rate of respiration, about fifteen to the minute, and care should be taken to begin it by expressing the air from the lungs, as it presumably contains an overdose of the anæsthetic.

In desperate cases, massage of the heart has been employed. This is best effected by introducing one hand through a high abdominal incision, and rhythmically compressing the heart, from which the thickness of the diaphragm and pericardium alone separates this hand, while the operator's other hand exerts counter-pressure over the sternum and ribs. In an appreciable proportion of the recorded cases the patient has recovered.

Patients who become *cyanosed* do so as a rule from some mechanical obstruction. The mouth must be opened by a mouth-wedge or gag, the tongue drawn forward, and artificial respiration begun. If it is found that air cannot be made to enter the chest, and no obstruction can be felt at the orifice of the larynx, tracheotomy or laryngotomy must be performed. As already stated, it is, in exceptional cases, necessary to inflate the lungs through the tracheal opening before natural respiration can be re-established. Opening the external jugular vein, and allowing a few ounces of blood to escape, sometimes does good.

**Delayed Chloroform Poisoning.**—This is a term applied to a group of symptoms which have been noticed chiefly in children after the administration of chloroform, particularly in those suffering from some acute infective condition, such as appendicitis. Vomiting returns at the end of twenty-four to forty-eight hours, and is usually

coffee-coloured. There is a sweetish odour of acetone in the breath. The patient is restless, then delirious, and often becomes comatose in a few days. The condition is due to some disorder of metabolism, associated with the presence of acetone in the blood. Ether should be given in preference to chloroform to children suffering from acute septic conditions, as it interferes less with the excretion of the deleterious bodies that cause the symptoms.

### LOCAL ANÆSTHESIA

The operations that can be performed under local anæsthesia are those in which the field of operation is comparatively limited and superficial. It is to be borne in mind that the various tissues differ in their sensibility: skin and periosteum are highly sensitive, while fat, muscle, and bone denuded of its periosteum are much less so. The parietal peritoneum is very sensitive to all forms of stimulation, but the visceral peritoneum and most of the abdominal viscera can be handled almost painlessly without an anæsthetic. Hence, if the abdominal wall and parietal peritoneum are infiltrated with a local anæsthetic, such operations as herniotomy, gastrostomy, or colostomy can be performed without a general anæsthetic.

The drug originally employed to produce local anæsthesia was cocain hydrochlorate, but it is liable to cause alarming syncope, which in some cases has proved fatal. The best known substitutes for cocain are: eucain lactate, stovain, tropacocain, and novocain. Le Brocq has recently investigated the respective merits of these, and finds that eucain and novocain are the least toxic, and that novocain is less irritant to the tissues than any of the others. Stovain is nearly as toxic as cocain itself, and, while its anæsthetic value is higher than that of eucain or novocain, it is much more irritant than either.

The addition of adrenalin to the solution of any of the above increases its anæsthetic value and diminishes its toxicity, probably by localising its action to the site of injection.

**Infiltration Anæsthesia.**—In this method the solution is injected into the subcutaneous tissue in sufficient amount to produce a moderate distension of the whole field of operation; marked blanching of the skin appears in a few minutes, from the vaso-constricting action of the adrenalin. The incision may be made in ten to fifteen minutes, and the anæsthesia lasts for an hour or two. The drug selected is dissolved in normal saline solution, and the strength of the solution should be about  $\frac{1}{4}$  or  $\frac{1}{2}$  per cent. Cocain is destroyed by boiling, but the others can be sterilised by heat without losing their analgesic action. Adrenalin can be added after the sterilisation. As much as four ounces of the solution may be used, though this quantity is not often necessary. Cocain should not be given in doses exceeding one grain.

**Regional Anæsthesia.**—If cocain or one of its substitutes is injected into, or even immediately around a nerve trunk, both motor and sensory impulses through the nerve are blocked. Oberst has pointed out that fingers, toes, and extremities generally can be rendered anæsthetic by treating the nerves supplying them in this manner. He applies a tourniquet on the proximal side of the seat of injection, to localise the effect.

Bier applies a broad elastic bandage both above and below the field of operation, and injects the solution into a large superficial vein, such as the saphena or the basilic. He uses from 50 to 80 c.c. of novocain solution, of a strength of  $\frac{1}{4}$  to  $\frac{1}{2}$  per cent. The part between the bandages becomes anæsthetic first, then that on the distal side of the lower bandage. By removing the distal bandage before the wound is closed, the drug is to some extent washed away, and the risk of toxic effects lessened.

**Spinal Anæsthesia.**—It has been shown that the injection of cocain or one of its substitutes into the spinal sub-arachnoid space by lumbar puncture induces anæsthesia in the areas supplied by the lower dorsal, lumbar, and sacral nerves, and renders possible the performance of operations on the lower extremities, rectum, and pelvic organs, without pain.

There are two different methods in use. In the one, the most distinguished advocate of which is Professor Bier, the solution used is *isotonic with the cerebro-spinal fluid* (s.g. about 1007). Tropicocain (2 per cent.) is used, without adrenalin, .05 grammes of the drug being injected. A little cerebro-spinal fluid is drawn into the syringe and allowed to mix with the anæsthetic before injection. Barker of London uses a 5 per cent. solution of stovain, in a watery solution of glucose with a specific gravity of 1023, without any adrenalin. This is heavier than the cerebro-spinal fluid. Before making the injection, the patient is laid on the side, with the thighs flexed on the body, and with the pelvis more or less raised from the table, according as a high or low anæsthesia is required. After injection, the only movement of the patient permitted is to roll him over gently on to the back. Rehn of Frankfort has demonstrated that even with this method the drug reaches the ventricles of the brain in 10 to 25 minutes. He has also demonstrated degenerative changes in the brain and cord of animals subjected to spinal anæsthesia.

Accounts of the results of spinal anæsthesia are improving, but the method is still not suitable for general use. The motor and sensory paresis not uncommonly spreads to an undesired height, and may involve the muscles of respiration. Some faintness frequently occurs a few minutes after the injection, from the relaxation of the abdominal muscles (Barker). Deaths on the operating table have been frequent, but, as many of the

patients have been *in extremis*, the mortality from the injection *per se* is difficult to calculate. Probably the mortality is as high or higher than that of chloroform, and much higher than that of ether. Kader of Cracow had four deaths in 1907 cases. Severe headache, often very persistent, is a common sequel. Persistent squint has also been recorded.

Although, by placing a physiological block on the spinal cord, the method undoubtedly reduces post-operative shock, it cannot as yet rival inhalation anæsthesia for safety, reliability, or convenience. In a small percentage of cases it has proved impossible to introduce the needle into the spinal theca.

**Freezing with Ethyl Chloride.**—A limited area of the skin may be rendered anæsthetic by freezing it with a spray of chloride of ethyl projected through a fine nozzle from a glass or metal cylinder. The cylinder is held at a distance of eight to ten inches from the skin, and the spray directed on to the area to be incised. After a few seconds, the skin becomes hard and white in round patches, which coalesce as it freezes, and it remains insensitive for a minute or two. Only short operations, for example the incision of an abscess or a whitlow, or the insertion of an aspirator needle, can be carried out under the anæsthesia produced by this method.





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